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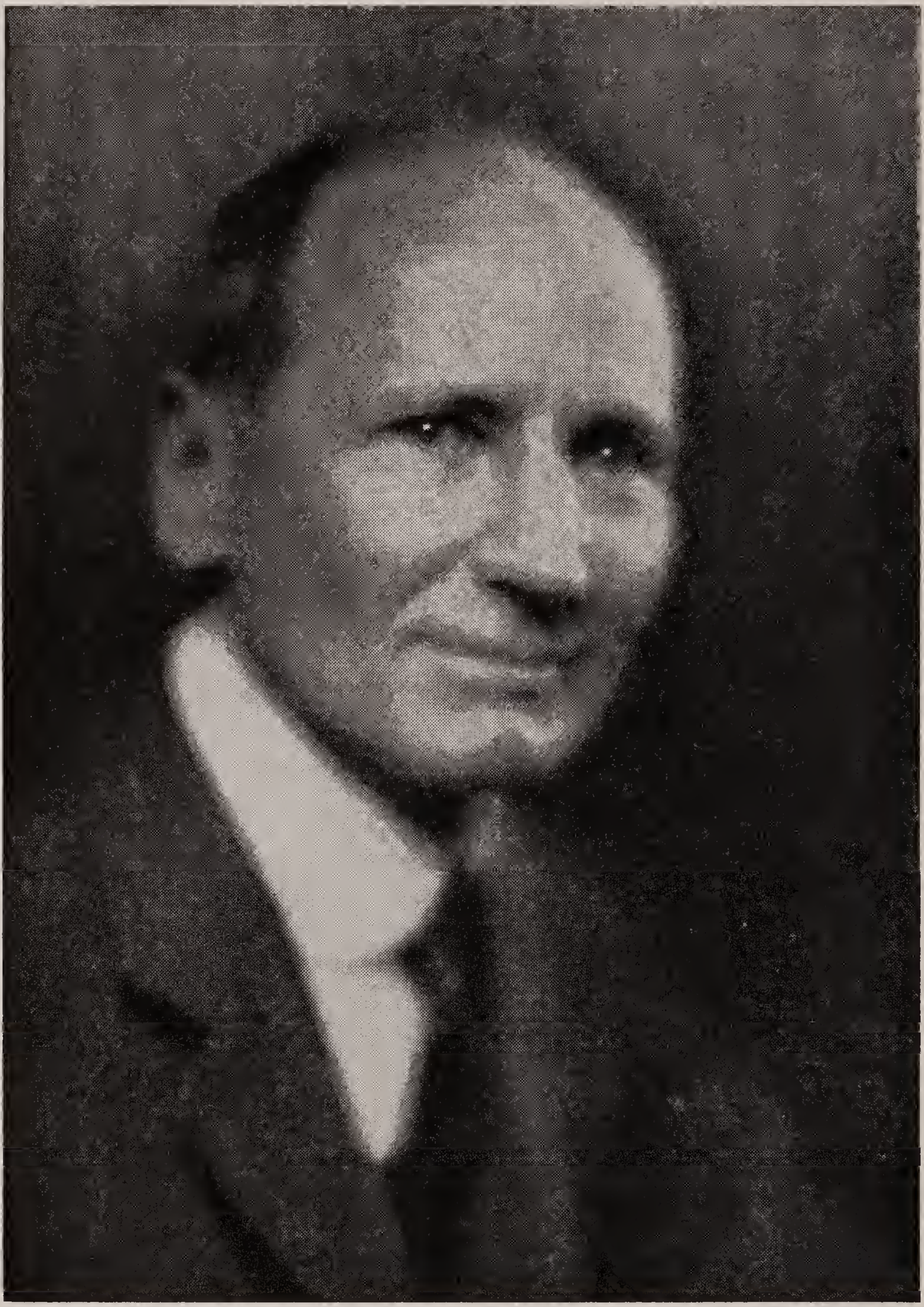

The late Gustavus E. Pfeiffer, an outstanding philanthropic leader, was concerned particularly with the problems of blind persons. He served as a Trustee of the American Foundation for the Blind from 1932 to 1953. The Foundation which bears the name of Mr. and Mrs. Gustavus E. Pfeiffer felt that the subject matter of these Proceedings *was clearly an extension of his own interest in sound research applied to the cause of human welfare. This book is dedicated to him and to our recommitment to his ideals.*

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PROCEEDINGS OF THE
INTERNATIONAL CONGRESS ON

TECHNOLOGY AND BLINDNESS

GENERAL CHAIRMAN: JEROME B. WIESNER
ASSOCIATE CHAIRMEN: M. ROBERT BARNETT
N. CHARLES HOLOPIGIAN
EDITOR OF THE *Proceedings*: LESLIE L. CLARK

VOLUME III

Panel III—Sound Recording and Reproduction

CHAIRMAN: HERMANN SCHERCHEN

Panel IV—Adapted and Special Purpose Devices

CHAIRMAN: JOHN C. COLLIGAN

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FOREWORD

This volume is the third in a series of four which contain the Proceedings of the International Congress on Technology and Blindness, held in New York on 18 through 22 June, 1962. It differs from the first two volumes in that it contains papers from not one but two separate Panels of the Congress, those on Sound Recording and Reproduction (Panel III), and Adapted and Special Purpose Devices (Panel IV). The papers and discussion from these two Panels, together with the Catalog Appendix (Volume IV), comprise what is perhaps the more pragmatic, rather than the more theoretical, portion of the Congress. Panel III deals with the present status and future development of the talking book, both here and in other countries of the world. Panel IV takes up in detail the several areas of education, vocation, and recreation in which applications of technology to solve some persistent problems of the visually impaired have led to useful everyday devices for the individual.

The organization of the papers in this volume reflects the emphases developed during the course of the international survey of technical devices, a project undertaken by the American Foundation for the Blind during the period 1960 to 1962—emphases which pointed out those areas in which much advance has been possible, and those areas in which we are presented with fresh challenges. N. Charles Holopigian was the Coordinator of the survey; L. L. Clark was Assistant Coordinator; and M. Robert Barnett was Principal Investigator. The survey actually gathered much material relevant to the several areas of the Congress, and the arrangement of Panels and Sections of the Congress was made during the course of the survey. Additional data from the survey will be found in Volume IV, the Catalog Appendix.

The publication of this report was made possible through a grant from the Gustavus and Louise Pfeiffer Research Foundation, to whom we express grateful acknowledgment.

While the American Foundation for the Blind was privileged to carry out the responsibility of the survey and the details of the Congress, it is apparent that no such study is ever accomplished by just one organization. The organizations and individuals who cooperated with us included virtually all those who were aware of a contribution they had to make; all of them should be commended for a fine example of an unselfish willingness to share.

Projects of this type are also expensive. The American Foundation for the Blind wishes particularly to acknowledge the financial support of the Office of Vocational Rehabilitation, Department of Health, Education, and Welfare; the National Science Foundation; the Irene Heinz Given and John LaPorte Given Foundation; Howe Press of Perkins School for the Blind; and the Gustavus and Louise Pfeiffer Research Foundation. Whatever degree of success the survey and the Congress enjoyed would certainly have been impossible without the assistance of these organizations.

The American Foundation for the Blind also wishes to recognize the invaluable cooperation of the American Foundation for Overseas Blind, and the World Council for the Welfare of the Blind, in helping these projects in many ways. Our several national and international bodies in the field of education, rehabilitation, and social improvement of the lives of blind persons have pledged that this effort is not simply a burst of enthusiasm, but that its real findings will guide many of our future activities.

It is our hope that the discussions included here will stimulate further exploration into the applications of technology to the everyday problems of the visually impaired individual. Surely there is much yet to be done in the area of automatic teaching, discussed here just so much as to tantalize our interest; and in the area of applications of technology to solving some of the most pressing problems faced by visually impaired persons in the many emerging nations.

The Trustees and Staff of this Foundation believe that the original objectives of the international survey, while specifically achieved, are still the objectives which those concerned with blindness must continue to foster. Briefly stated, we must continue:

1. To establish those avenues of technological science through which research and testing show the greatest potential for the material accomplishment of practical devices for use in the education, rehabilitation, or personal lives of blind persons.
2. To analyze as objectively as possible the practical results of existing and past avenues and basic premises upon which technical research has been founded.
3. To collect for purposes of dissemination to all present and future investigators and engineers a comprehensive library of existing re-

search and/or devices with objective evaluation of the merits of each.

4. To provide for an intensive and concentrated exchange of scientific opinion and information through national and international conferences.
5. To provide a base for more effective coordination among all researchers through a continuing system for collection, evaluation, and dissemination of developments in the field anywhere in the world.

M. Robert Barnett
Executive Director
American Foundation for the Blind

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Panel III—Sound Recording and Reproduction

INTRODUCTION

When, in early 1960, we planned in outline form what should be included in the meetings of the International Congress, the question of sound recording and reproduction took its place as a major concern quite naturally. The talking book has become perhaps the most celebrated of the "indirect" routes of access to the printed word that is available to the visually impaired precisely because it has so greatly extended the numbers of readers among the blind population. Furthermore, recent technological revolutions in every field of engineering have been felt with particular strength in audio engineering, in part because of the enormous demands made by media of mass communications; and in part, perhaps because of the keenness of interest of a whole new generation of listeners to reproduced speech and music (whose appetite for good sound quality was weaned from console equipment to component equipment).

There were a number of practical questions to be considered as well. Among them were the application of advances in audio technology to the talking book; the design criteria for the possibility of adapting tape techniques to the talking book; and the bases for sensible consideration of the tape vs. disc controversy which has been gathering strength for several years. These questions assume additional importance when we consider the natural growth of the populations in all countries, and the concomitant increase in the potential audience for talking books over the next 20-year period.

One of our major concerns in planning this Panel was that we would not become so involved in the technical matters inherent in both practical and theoretical issues that we would forget the full human implication of our efforts: the needs of the reader. And we were fortunate in securing as Chairman Professor Doctor Hermann Scherchen. Many in our audience know Professor Scherchen as a world-famous conductor, whose musical activities cover an almost unbelievable range of styles, periods, and techniques. They may even have been familiar with his scholarly work, for example, in arranging the orchestral transcription of *The Art of the Fugue,* for his championship of the new music (over the past several decades), and for his continuing interest in the new art of composition of so-called "computer music." Yet comparatively few persons outside the audio fraternity are familiar with the fact that he is also an editor of the *Gravesaner Blätter,* a periodical whose scope is as broad as its editor's interest: from issues in musical esthetics to matters of sound reproduction in the most technical sense. Nor were many persons aware of Professor Scherchen's other technical interests, ranging from the perfection of a fresh approach to the reproduction of stereophonic music (via a spherical loudspeaker design with servo-controlled radiation with a constantly rotating point source), to intricate problems of the reaction of the human body to sound energy in various combinations and at varying levels of energy impact. These matters he pursues at his laboratory (the Elektroakustiches Experimentalstudio) in Gravesano, Switzerland. It is all the more to be regretted, therefore, that he was too exhausted upon arrival at the Congress (from an overseas flight from Warsaw, where he was UNESCO consultant in some recent recording sessions in Poland) to conduct the meetings of Panel III. In asking me to take on this responsibility, under his guidance, he admitted, too, that "American" speech followed only on the heels of his understanding of "English" as it is spoken in the rest of the world—and his sense of responsibility to the participants prompted his statement that only the most acute and quick understanding of the verbal interplay would be just adequate to this task. For the same reasons, then, I agreed on this occasion to introduce the reader to the papers and to a discussion of the Panel. But I should like the reader to be aware of his guiding spirit, the spirit of a truly "universal" man as such men were best known in the Renaissance, in what follows.

Perhaps the most important caveat Professor Scherchen gave us was contained in his opening remarks to the Panel III participants:

> "We are here together to analyze the most important means of communicating information through electronics to the blind: the talking book on tape or records. Industry, which has not really seen a very profitable side to this communications link, has taken only a charitable interest in the problem. Thus the blind must accept gratefully whatever industry finds time to develop for him. But man is more—and is more important than machines. This is why I somewhat regret that the work of this Panel does not take into consideration also the human factor, that is, the problems for the blind arising in operating tape books, recording cassettes, and discs. The Chairman is, of course, not expected to read a paper; but if you feel with me the importance of this problem—of the human factor— then I will propose to lay before you some personal thoughts which attempt some solutions to a few of the difficulties which arise in the use of the talking book."

Professor Scherchen was in fact so ill and so exhausted from his unending travelling during the preceding six-month period that he was unable to present these ideas to the participants during the meetings. One will be found, however, in the catalogue appended to this volume: it represents a solution to the problem of introducing tape leaders onto the take-up reel of a tape reproducer of standard open-reel design. There were several other matters about which he had developed extensive arguments and proposals, and for these I would urge the reader to consult forthcoming issues of the *Research Bulletin* of the division of Research of the American Foundation for the Blind. I understand also from Professor Scherchen that the format of the *Gravesaner Blätter* has been revised for 1963 onwards, and will contain a new section on Vision and Audition. The reader will find additional and I am sure fascinating developments there as well.

Panel III was designed to provide a forum within which the participants could discuss the technology and the art of sound recording and reproduction for the blind and the visually impaired. This naturally involves the talking book; it also involves both disc and tape recording and reproduction. The Panel is divided into two parts, dealing with the disc talking book, and the tape talking book respectively.

Monsieur Bernard's figures tend to bear out a contention made universally to us long before the Congress: that the scope of the disc talking book in Europe was rather limited. The disc talking book program in the United States is a different matter altogether, however, and in Mr. Breuel's historical review of the establishment and development of the disc talking book program here we can see that a considerable audience is served. His main point, which we might well bear in mind throughout, is that due to the volume of the records produced, and the scope of services rendered under the Library of Congress program, the disc as a medium for the talking book is uniquely suited to the American scene.

Mr. Levens' paper is devoted to some considerations in the choice of the new $16\frac{2}{3}$ rpm disc for the talking book which was introduced this year; but he also gives us considerable additional information which will allow the more thoughtful reader to apply his own standards and to come to his own conclusions about the disc as a medium. Perhaps just one point should be underscored. The American Foundation for the Blind which has conducted considerable experimentation for the Library of Congress disc talking book program, has had experience with systems of greater storage density than the $16\frac{2}{3}$ rpm system. In terms of the library system, however, these offered no particular advantage. Greater storage density implies much larger editions and yet better storage containers—conclusions which the reader can read himself using Mr. Levens' data. It is evident that one very quickly reaches a point, just beyond the new slower-speed system, where the cost of the recorded material becomes less than the cost of a container. Thus, until an efficient low-cost container is developed, the cost advantages of a higher-density storage recording system cannot be exploited. In addition to this difficulty, of course, a special reproducer is required whose dependability is not as proven as current machines. There may be some exceptions to this rule (for small runs, for example, on embossed discs), but the quality level implied in the current U.S.A. program imposes stringent requirements on the recording system.

One other means of increasing storage density was mentioned during the meetings but not pursued further: time compression. The interested reader is referred to the use of this technique as discussed in Panel I (Volume I) of these *Proceedings*. Disc indexing, another issue brought up and dismissed almost as quickly, has been dealt with ingeniously by Professor Scherchen and his solution will appear in an early issue of the above-mentioned *Research Bulletin* along with a description of his combination stereophonic disc and tape recorder/reproducer.

In order to provide a common language for the evaluation of *systems* proposed and used for talking books, the Chairman asked Mr. Bray of the Library of Congress to undertake the difficult task of analyzing the costs of producing a disc talking book and, later, of producing a tape talking book, taking every technical advance into account. He has responded with courage and enthusiasm in meeting this very difficult assignment, and we now have before us a beginning at least of a mode of analysis which may well prove of great use in the future.

The tape talking book has achieved a good deal of notice (if not notoriety) of recent date, due in part to the boldness and imagination of our British colleagues in planning and executing a fresh and novel approach to such a system. We were fortunate indeed to have a very complete discussion of the British Tape Talking Book system from the administrator of the program currently, Mr. John Adam. As we expected, this paper provoked a good deal of discussion, much of it quite lively, and I think it fair to say that the participants were impressed with the system and with the thoughtfulness of the plan for conversion from disc to tape usage which is currently under way in Great Britain and the cooperating countries using the system. One matter clearly not resolved was that of copyright, and it would appear from this vantage point (after the discussion) that a special study of this question would repay our efforts richly.

The tape talking book in cassette form is, in the United States, so far an experimental system (although talking books on tape are not at all rare in reel-to-reel form). Mr. Korb discusses the efforts so far.

In Continental Europe and in Scandinavia the tape talking book has come into its own. Here, the problem of huge editions of books is not involved; rather, the concern is for convenience and for speed in circulation. The use of tape is covered in the next two papers, including the very interesting use of the medium for a talking newspaper.

The meetings concluded with one paper on tape duplication which, although it covers the technical questions involved, does not treat specifically of the difficulties inherent in the generation of a multiplicity of talking book systems on tape, each with its own requirements as to equalization, tape speed, type of tape, and the like. Since one of the ways to achieve economy in this field is through a certain amount of standardization, a careful appraisal of the possibilities for achieving interchangeability among the several systems (in use and proposed) may effect some important economies which can be used to increase the talking book service in scope and depth. Another method of achieving standardization (that of settling on the commercially-produced reproducer/recorder) is discussed by Dr. Boiten in his paper; he was also kind enough to provide us with a summary of the Panel on Professor Scherchen's behalf.

The reader will have noted in the review just given that the term *system* is often italicized. This emphasis is deliberate since it seems to this observer that only by considering this medium of communication in its totality can we assess its economy, its potentiality, and its adaptability to varying conditions. Various attempts were made by the participants to give such an analysis for the conditions under which the systems they speak of actually operate. But it is clear, nonetheless, that the reader has not been brought to the point where he can generate as yet a "figure of merit" for each of the systems discussed. It is equally clear that a discussion of this type would be of great usefulness for those countries who have yet to decide upon a suitable medium for the talking book programs for their own visually impaired people. It is to be hoped that both the readers and the participants will meet this need by considering what elements it would be necessary to include in such a discussion and then to share their reflections with us. I should like to extend an invitation to any reader, who wishes to consider this problem, to submit a paper for publication in the *Research Bulletin,* where, we may hope, we can continue our considerations of the talking book which have only begun in the meetings reported on here.

L. L. CLARK

REPORT ON THE EUROPEAN DISC TALKING BOOK PROGRAM

MAURICE R. BERNARD
American Foundation for Overseas Blind, Paris, France

As the Chairman has already indicated to you, there is very little activity currently under way in Europe using the disc talking book. The only countries in which talking books on disc still exist, in fact, are France and, to a much smaller extent, Austria. In England the disc talking book will die a natural death as the change-over from disc to tape in cassette form takes place over the next three years (i. e., the end of 1966).

In France most blind persons find it difficult to buy tape recorders or reproducers for these are comparatively expensive. Almost everyone has a disc playing machine, however, hence there is a demand for talking books on discs. Those who do own both a disc playing machine and a tape reproducer usually prefer talking books on tape in any case.

All discs available in France for the use of the blind are edited by the Union des Aveugles de Guerre, or U.A.G. (Association of the War Blind). The discs are distributed very widely, as Table 1 shows.

At the present time 762 titles are available on discs and 464 titles on

TABLE 1

DISTRIBUTION OF DISCS PRODUCED BY THE ASSOCIATION OF THE WAR BLIND IN FRANCE

Area	*Agency*
Northern France	Phare du Nord
France—all other regions	Regional offices of the Association Valentin Haüy; Association of the War Blind
Belgium	Ligue Braille (Brussels)
Canada	Canadian National Institute for the Blind
Israel	National Library for the Blind (Nathanya)
U. S. A.	New York Public Library

tape. About 60 titles are recorded every year, and 60 copies of each title are pressed in disc form, while only 4 copies are made on tape for circulation. Discs are recorded at 16 rpm; the normal playing speed for tape is 3¾ in./sec.

The Association Valentin Haüy, in Lyons has garnered about three thousand subscribers for discs in all of France, under the particularly dynamic leadership of its Chairman, Madame Max Roux. These subscribers are distributed as in Table 2.

TABLE 2

SUBSCRIBERS TO THE DISC PROGRAM OF THE ASSOCIATION VALENTIN HAÜY (LYONS) IN FRANCE

City	*No. of Subscribers*
Lyons	300
Paris	2000
Marseille	300
Nantes	100
Rennes	100
Nancy	100

Another very active organization is L'Amicale des Aveugles Protestants de la Cause (Union of Friends for the Welfare of the Protestant Blind). This group, founded in 1923, initiated its activities with a monthly braille publication entitled *L'Étoile dans la Nuit* (A Star in the Night). Since 1959, they have produced recordings on tape and, to a much lesser extent, on disc. The masters are recorded in the studios of the Association of the War Blind in Paris by professional actors and actresses, drawn largely from the Comédie Française. In addition to a series of titles covering material of general cultural value, history, archaeology, biography, fiction, and the like, this group has also made available a recording of the Bible, thus following the example of our friends in Copenhagen.

This meagre inventory virtually exhausts the major effort in disc recording in Europe. The program is certainly declining in quantity, and it can be stated frankly that the future probably lies with programs of tape production, either on the usual one-quarter inch tape, or in tape cassettes.

REPORT ON THE UNITED STATES DISC TALKING BOOK PROGRAM

JOHN W. BREUEL
American Foundation for the Blind, New York, New York

In the late nineteen twenties the American Foundation for the Blind (AFB) began to give thought to the problem of providing another means for communication to the blind in addition to braille. Others in work for the blind had also realized this need and, in cooperation with the Foundation, ways were sought to meet the need. The spoken word recorded on phonograph discs was an obvious answer even then; indeed Thomas Edison had suggested the application of his invention of the phonograph to bring reading to the blind as long ago as 1878. The advantages of such a method of reading over braille were many, especially in the case of reading done for recreation and relaxation. First of all, it can reach a larger audience, for only a small percentage of the blind can use braille at all. Second, the enjoyment of a reader is increased if a book is read by a professional actor who gives the content of a book skilled interpretation in the reading. Both advantages were realized at the outset.

Before such an ambitious conception could be realized, however, several obstacles which appeared insurmountable had to be overcome. The major obstacle was one of cost, which depended on the state of the art at the time: a book of any size could require three or four dozen of the 12-inch, 78 rpm discs then in use. In addition, the discs were rather heavy; they were broken easily; and had a maximum playing time of about nine minutes, which necessitated almost constant attention by the reader who played them on the type of small home phonograph (with what we now call a "manual" turntable) then available.

At about the same time, the radio industry and the motion picture industry were beginning to utilize recordings made on 16-inch discs which turned at $33\frac{1}{3}$ rpm, with a pitch similar to that in use by the record industry for many years.

A great deal of thought had been devoted to this project possibility by the Executive Director of the AFB, Mr. Robert B. Irwin, and by Mr.

M. C. Migel, its President. In 1931 they were successful in obtaining a grant of $25,000 from the Carnegie Corporation, whose interest had been stirred by its preliminary tests of experimental discs recorded at 33⅓ rpm. The grant was used to set up a studio and laboratory, and to conduct further experimental work aimed toward perfecting a disc that would permit acceptable speech reproduction and a playing time of 15 minutes on each side of a 12-inch recording.

With the advent of semiflexible record material introduced at the same time, the reasonable goal of a half-hour playing time and reasonably light weight for recorded books seemed at least within sight. For the user the advantages of less physical bulk and the need for attention to the record only every 15 minutes were considerable. In addition, it was decided that the recording would utilize constant rotational speed rather than constant linear velocity, for experimental work indicated that the latter method required complicated and expensive (and unreliable) drive systems.

The first talking book records had the following characteristics:

1. 12-inch diameter
2. Double faced
3. Semiflexible material
4. 33⅓ rpm
5. Recording pitch of 150 lines/inch
6. .003 inch stylus tip radius
7. For replay using standard steel needle.

The distribution of records once they were made was as important as the development of a satisfactory long playing recording. The library as a distributing agency appeared to be the best solution to this problem, for braille products had been distributed with this system, and it would seem natural to develop a distribution program for the talking book in this way as well. The required funds were authorized by the Pratt-Smoot Bill which appropriated the sum of $100,000 per year to the Library of Congress for books for the blind. The Bill became law on 3 March 1931. The books were to be deposited in regional libraries which would undertake their circulation to the blind user. Note that the law mentioned ". . . books for the blind," and not talking books specifically; in 1934 the AFB was instrumental in having the law amended to include talking book recordings. Since that time the appropriations for the talking book records, and for the machines on which to play them, have steadily increased, year by year.

At the time the program was started, the Library of Congress distributed talking book records to 27 regional libraries, all in the United States. Today there are 31 regional libraries which serve both the United States and its possessions. They distribute records to the homes of blind readers located in their own geographical regions through the U. S. Postal Service, which provides free transit of reading matter for the blind. A special container is used for the records.

Even in the first year of the program a small number of titles were distributed, and the sudden demand for machines on which to play the discs required strenuous efforts to supply them. At that time there were few, if any, home phonographs able to play 33⅓ rpm recordings. The Foundation developed a small, portable machine for the purpose, and several thousand were assembled during the ensuing years. They were sold at cost to blind readers, and to schools and organizations for the blind. As the demand grew, the supply was not sufficient, and the Library of Congress was able to obtain a Works Progress Administration (WPA) grant for the manufacture of talking book playback machines. (The WPA was a federally financed relief program which operated during the period of the Great Depression, i. e., 1930-1939.) The program was initiated under the supervision of the AFB and continued for many years. The reproducer produced was a simple phonograph player, incorporating an amplifier, loudspeaker, and a magnetic pickup using steel needles which were replaced after each playing. By 1942, 24,000 of these machines had been distributed; of this number 2500 were of the spring driven type for use in rural areas where electricity was not available from power lines. The latter type of machine used headphones for which the electrical energy was obtained directly from a crystal pickup. The distribution was made through agreements with state agencies for the blind, with allotment through apportionment according to the number of blind readers to be served. Eligibility of a prospective subscriber was made through the simple device of a notice sent to the state agency by the reader. The same system is still used, and distribution of machines is made through 55 agencies which serve all 50 states and U. S. possessions.

It might be emphasized that eligibility of the subscriber entitles him to the use of a machine at no cost to him, and free recorded book service as well.*

From the beginning of the talking book program, the AFB has maintained fully equipped recording studios where books ordered by the Library of Congress are read by professional readers—actors, actresses, radio and television announcers, etc. The American Printing House for the Blind in Louisville, Kentucky, set up production facilities and recording facilities also, only a few years after AFB's first experimental work and, together the two organizations have been able to meet the constant growth of demand over the past 25 years.

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* Eligibility is defined on the basis of a central visual acuity of 20/200 or less in the better eye with correction; or an angular field of vision which is 20 degrees or less. A certification from a qualified medical examiner to this effect must accompany the subscriber's request.

During the first few years of its operation, the talking book program at AFB was carried on in a relatively small operation: recording of the master discs, and shipping out the finished records. The records were made up into sets; boxed; and made ready for circulation by the libraries on receipt. The processing of masters and pressing of the records was done under contract to a commercial record manufacturer. This system appeared to work well in the situation in which there were peaks and valleys in commercial record production which could be filled by work such as our own. After World War II, however, production increases in talking book demand coincided with a very rapid growth of the commercial recording industry. It soon became evident that only by operating our own plant facilities for record plating and pressing could we satisfy our own requirements at price levels and on delivery schedules that were scaled to the needs of the talking book program. And in fact once some experience had been gained, the many advantages attendant to the control and integration of all steps from recording the master to pressing the disc were realized in the reduction of prices. Even with rising costs, it can be stated unequivocally that prices continue to fall due to improvements in manufacturing equipment and technique. In other words, the Library of Congress is able, with each reduction in cost, to purchase more books for the same number of dollars.

A significant change was introduced into the talking book program by the refinement of the microgroove disc process, beginning in 1950. Even at that time, recordings were made for playback with a ½ mil stylus tip radius. These new records call for new playback equipment, using refined pickups and styli, and the pitch of the recordings was increased several times, until in 1957 it was stabilized at 270 lines/inch. The new records enable significant lengthening of the playing time—to a half-hour per side—which is just double that obtainable on the first discs produced in 1934. The fidelity of the record is greatly improved in addition.

Present plans call for another change to be made by the end of the 1963 fiscal year, from 12-inch, 33⅓ rpm recordings, to 10-inch, 16⅔ rpm recordings. These records will enable a further 50 percent increase in playing time per record due in part to the slower speed and in part to a yet finer recording pitch. We will thus have available a 10-inch disc with a total playing time of one and one-half hours. In practical terms, this means another increase in the number of books possible for the same amount of dollar expenditure, along with a further decrease in the physical bulk of a recorded title. The obvious advantages in handling both for the user and for the regional libraries need no comment.

Magnetic recording tape, introduced at about the same time as microgroove techniques, enabled greatly increased efficiency in making the original master; starts, stops, and corrections can be made without serious loss of time in producing a finished master.

In current practice, the contents of the master tape are transferred to lacquer discs, which are the original recordings from which masters are plated. The lacquer discs ("lacquers") can be plated more than once, thus permitting second and third copies of masters to be made easily without the need for re-recording the book.

Five or six years after the start of the talking book program in 1934, there were approximately 500 titles available to blind readers through the regional libraries, and about 100 titles were added each year. The output of new records has, however, continued to grow each year, and at present the Library of Congress is able to supply about a million records a year. (This represents several hundred copies of each of approximately 400 titles.)

The American Printing House for the Blind and AFB also provide other special records under contract. The *Reader's Digest* is the most popular of these special production runs. Published in talking book form for over 20 years, it was recently changed to the new $16\frac{2}{3}$ rpm format, and 5000 copies are pressed every month. *Newsweek* is also recorded at the slower speed, with an edition of 800 copies every week. Monthly, bi-monthly, or quarterly publications, as the *John Milton Quarterly*, the *Christian Herald Quarterly*, the *Blinded Veterans Association Bulletin*, the *New Outlook for the Blind*, and the *Braille Technical Press*, vary in circulation from a few hundred to nearly 10,000 copies. About 50,000 Bible discs are pressed each year for the American Bible Society.

Mention should also be made of the embossed records made by Recordings for the Blind, an organization incorporated in 1951 to fill an important need for text and reference books which are usually required in small quantities. Volunteer readers supply original recordings on tape, and embossed disc copies are made from the tapes in the desired quantities.

Over 1200 titles on over 200,000 7-inch discs were produced in 1961, and the current catalog of books available has grown to 4600 titles.

Space restricts us to mentioning only in passing the many volunteer groups who make a substantial contribution to recorded material by making tape and disc recordings to individuals requiring special text materials.

The usefulness of the regional libraries distributing talking books can be said to have increased over the years as the number of records in circulation increased; one indication of their success is the steady rise in the number of blind readers who use the service. Their needs for machines are met by the Library also, for part of its annual appropriation is earmarked for manufacture of reproducers. At present there are more than 60,000 machines in use, all of which are capable of playing 33⅓ rpm discs. The oldest machines are now being replaced with two-speed models capable of playing both 33⅓ and 16⅔ rpm discs, in anticipation of the rapid rise in number of the latter in the near future. Nearly half of all the reproducers have been replaced by the newer model. Several hundred machines with spring wound drive systems and battery powered amplifiers are in use in rural areas. The growth of the talking book program of the Library of Congress can be illustrated by comparing current expenditures with the $100,000 per year spent during the first year or two:

New records	$750,000
New reproducers	400,000
Repair	60,000

The item for "Repair" highlights an important part of the program which has not yet been emphasized here. For some time repair of reproducers was carried on in a central depot located by the Library of Congress. This operation was soon abandoned in favor of decentralized repair facilities located in or close to the agencies through which the machines are normally distributed in each region; the latter method was found to be superior in effectiveness and in cost reduction. The parts required are supplied to the local agency, while much of the testing and repair work is carried on by local volunteer groups. The group is formed largely of Telephone Pioneers, who are experienced technical men.

The talking book program has been continually upgraded in quality whenever possible, from an improvement in recording quality to an improvement in fastening straps on the record containers, and a continual search is made for additional refinements to be added to the operation.

Financial and technical factors have contributed toward the solution of a series of difficulties, from the establishment of the first recording studios at the Foundation through a private donor's gift of $10,000, to the research and development work of the Library of Congress in cooperation with AFB on improving technical standards in the recording and reproduction of sound. Every effort is made to keep abreast of advancements in commercial recording techniques, and indeed cooperation has been extended on many occasions to assisting commercial producers to overcome manufacturing problems as much as help has flowed from them to us. This cooperative arrangement obtains to the present, and commercial firm representatives are invited to participate in the annual conference on talking book specifications called by the Library of Congress. The most important current emphasis in the program is the refinement of automatic record production apparatus, and the concomitant stricter quality control over the final product which is exerted at every stage in the process.

Keeping pace with progress also requires the latest and best in equipment. In the studio this requires the latest microphones, amplifiers, tape recorders, level limiters, and controls; in the disc master production the virtually automatic operation of tape playback, recording lathes, and associated equipment; in electroplating the installation of the most modern equipment with automatic regulation of temperature and plating current; and in the record molding phase, the use of high speed presses of special design coupled with the newest compound extrusion techniques. Only by making every effort to match the latest advances in the recording art can we achieve the goal of supplying more records at the lowest possible cost consistent with the quality standards which have been established.

Throughout this recital of technique and method, no mention has been made of the organization of services which implement the program in human terms. It should therefore be mentioned that the Library of Congress holds frequent conferences with those administering the program at the state and community level. The meetings are specifically designed to improve services by minimizing red tape; by determining the best use of the available books; and by providing the most efficient means of distribution of books and of reproducing machines.

THE EXTENSION OF PRACTICE: FUTURE PROSPECTS OF THE DISC TALKING BOOK

LEO M. LEVENS
American Foundation for the Blind, New York, New York

As Mr. Breuel has pointed out in his historical review of the development of the disc talking book system in the United States, a need was felt in the late nineteen twenties for an alternate method to braille as a communication medium for blind persons. For the reasons he outlined, it was felt by many that this need could be met by a suitable disc system. The extensive research and development work done at that time and directed toward the provision for this need culminated in a system which can be said to have been really advanced for its time. Most important of all, it did meet the requirements of a mass communication medium for blind people.

Among its contributing characteristics were the following: In the first place, it was economical, so that a great number of persons could be served at low unit cost. Second, it met the aesthetic and semantic requirements for such a system, for with professional readers working under the direction of a competent observer, material could be presented accurately and yet maintain the interest of the listener. Third, the system was simple in design, rugged in use, and easily maintained for top performance in the field. The improvements which were made in the system came gradually, as the state of the recording and reproduction art developed further, and as better components gradually became more widely available.

It was in this way that the advances represented by the microgroove record were incorporated smoothly into the disc system, for when microgroove tone arms and cartridges became available, it was possible to raise the recording pitch from 150 lines/inch to 200 lines/inch, and finally to 270 lines/inch. Each of the steps upward was taken only after considerable experiment and intensive tests had shown the feasibility of such extensions. The testing and experimentation undertaken before the adoption of the microgroove system can thus be taken as the background for the desire to extend the techniques in the thinking and development necessary for a 16⅔ rpm disc system. One of the most important spurs to such development has been (and continues to be) the need for constant cost reduction while maintaining the quality standards of the disc system as it improved step by step; hence, the search has been unending for yet higher density storage systems.

To underscore the evolutionary character of the disc system as used for the talking book, it might be pointed out that only in the early nineteen fifties were low cost two-speed motors finally available which were also sufficiently reliable for this kind of application. The decision was made, therefore, to incorporate a two-speed motor in all talking book reproducers as soon as possible. This decision was implemented in the "D" series of machines. Each succeeding year saw more small improvements in terms of reliability and reduction of over-all cost, and we can now say that we have reached a point at which a majority of the talking book readers in the United States can utilize the slower 16⅔ rpm recordings.

The first appearance of the slower speed recordings was in a series of experimental discs produced by the American Foundation for the Blind; these were followed shortly by the publication of two periodicals. The experience thus gained was encouraging enough that it was decided to go forward with a 16⅔ rpm program for the talking book.

The development of this program—which I have done no more than to highlight for you—is based on the same criteria established for the very first discs used for this kind of application. That is to say, the talking book system must be economical, simple in design, reliable in operation, and maintainable in the field; furthermore, it should use readily available components of proven reliability. In contrast to the user of high fidelity equipment as he is usually drawn, there can be no more disastrous consequence for the talking book user in this system than equipment which is fussy, in need of constant adjustment, expensive, and which requires skilled and lengthy technical attention.

The specifications for the new 16⅔ rpm system are shown in Table 1 below.

Although many of the specifications are self-explanatory, I should like to comment briefly on several of the parameters chosen in order to make it clear why they were chosen at the outset.

1. The vinyl record material already in use is satisfactory; future interest might be directed, however, toward a yet tougher (more rigid) material such as the nylon types (e.g., Delrin) for better wear qualities, and to-

TABLE 1

SPECIFICATIONS FOR THE LIBRARY OF CONGRESS
$16\frac{2}{3}$ RPM DISC TALKING BOOK SYSTEM

Material:	High quality vinyl resin with lubricants, stabilizers, and, color, with possible addition of antistatic compounds
Diameter:	$9\frac{7}{8}$ in. ± 1/16 in.
Weight:	3 ± $\frac{1}{2}$ oz
Thickness:	.060 in. ± .020 in. at the leadout groove
Center Hole:	.286 in. ± .002 in.
Concentricity:	Within .010 in.
Diameter of First Groove at Recording Pitch:	$9\frac{1}{2}$ in. Start 2 grooves after reaching recording pitch; Coarse pitch spiral lead in groove
Minimum Inside Diameter:	$4\frac{1}{4}$ in. with 4-pitch leadout spiral to $3\frac{3}{8}$ in. concentric (within .010 in.) circular groove
Speed:	$16\frac{2}{3}$ rpm
Pitch:	270–300 lines/inch ± 5 lines/inch
Groove Shape:	87 degrees cut with stylus tip radius .0002 in. to .0005 in. Groove/land ratio 70:30 (±10 percent)
Recording Characteristic:	Maximum stylus velocity at 1000 cps; 3 cm/sec
Bandwidth:	50 to 6000 cps within ±2 db; constant amplitude 50 cps to 500 cps and constant velocity above 500 cps to 6000 cps
Distortion:	At minimum compatible with entire recording system, measured to standards of the recording industry
Noise Level:	46 db or more below maximum stylus velocity
Recording Time:	90 minutes
Labels:	Braille on side 1 and odd sides; Inkprint on side 2 and even sides

ward various antistatic compounds which inhibit the collection of dust in record grooves.

2. The 10-inch diameter of the new disc was chosen as a compromise between the otherwise technically superior 12-inch disc and various requirements for easier shipment and storage, voiced by regional library personnel. The impossibility of inserting the larger package into postal mail boxes for free mailing service is solved by the smaller dimensions of the new disc.
3. Weight and thickness were chosen to maintain ruggedness while contributing minimum bulk.
4. The minimum recording diameter was set so as to maintain the quality standards applicable to low distortion levels already established in the talking book discs; similarly, pitch and groove shape were chosen to achieve a maximum storage capacity and to minimize tracing problems and groove echo. The concentric circular groove is used to activate a stop switch on the reproducer. A further reduction in groove echo will occur with the change-over to a 0.7 mil stylus (diamond).

5. The recording characteristic is chosen for maximum intelligibility and inherently greater durability in use than the usual microgroove disc; diameter equalization and compression techniques are used to maintain as high a signal/noise ratio as practicable.

In sum, our feeling is that the above are some of the most important features of a disc system which we believe to be simple, very rugged, and economical.

The performance characteristics of the three record systems have been explored at considerable lengths in the laboratories of AFB. Table 3 presents, in fact, a summary of experimental data which were obtained in measurements made of all three systems produced for experiment in our organization. The physical characteristics of the three types of discs, including their diameter, the pitch used in recording, the groove shape, the stylus velocity, the record weight, the playing time, and the playback stylus, are contained in Table 2.

As can be seen in Table 3, the experimental discs were played on a standard microgroove machine using a 1 mil stylus. The records were played 100 times each. After 25, 50, 75, and 100 playings of each record side, the test process was interrupted for a series of measurements and a listening evaluation was made on the last playing of each stopping point. The experiment was terminated after 100 playings of each side since to continue would generate data of academic interest at best. The results are largely self-explanatory.

The cost comparison in Table 4 is a straightforward description of the three record systems. It represents a normalized cost/hour comparison of the materials for the three systems. The reader will note that the cost/hour for all three systems decreases with an increase in the number of records produced—a perfectly general trend. The reduction becomes greatest in the case of the $8\frac{1}{3}$ rpm system; the $16\frac{2}{3}$ rpm system lies somewhere between the other two. Note, however, that these costs are given exclusive of record containers. In order to take advantage of any reduction in cost, the books recorded on discs must be packed in a manner consistent with the reduction, and the requirement is met by the arrangements detailed in Table 4 as well.

To what improvements in the disc system can we look in the future? In my opinion, we can expect that the cost of talking book records will be reduced, in part due to more efficient processing methods, in part due to the use of more automatic equipment in their production. Record life will surely be extended through the use of newer plastic compounds, including

TABLE 2

CHARACTERISTICS OF PRESENT, FUTURE, AND EXPERIMENTAL LIBRARY OF CONGRESS DISC TALKING BOOK SYSTEMS

	RECORD SYSTEM	(RPM)	
Characteristic	$33\frac{1}{3}$	$16\frac{2}{3}$	$8\frac{1}{3}$
Diameter	12 in.	10 in.	12 in.
Pitch	270 lines/inch	300 lines/inch	350 lines/inch
Groove (Cutting Stylus Radius)	.00025 in.	.00025 in.	.00025 in.
Stylus Velocity	4.5 cm/sec	3 cm/sec	2 cm/sec
Record Weight	5.5 oz	3 oz	5.5 oz
Playing Time	1 hr	$1\frac{1}{2}$ hrs	6 hrs
Playback Stylus Tip Radius	.001 in.	.001 in.	.001 in.

the above-mentioned Delrin type materials. We can expect that signal/noise ratios will widen still further when antistatic compounds are added to record material before pressing.

On the other element in the user's equipment, the disc reproducer, we can envisage similar advancements. We can expect, for example, that record wear will be reduced by the use of improved pickup cartridges and tone arms. The whole machine, in fact, should become smaller and lighter, and it will incorporate transistor elements for ruggedness and long life when the cost of these components is reduced.

As to turntable speed, it can be expected that, at least in the United States, the $16\frac{2}{3}$ rpm talking book record will gradually augment, and then replace, the $33\frac{1}{3}$ rpm disc.

For the convenience of the reader, the advantages and the disadvantages of all three disc systems are outlined in Table 5, which comments on each system from the point of view of the economic, technological, and human elements as these elements have distributed themselves in importance according to our experience and knowledge of the use of the talking book program. The format is deliberately designed to allow the reader to arrive at his own "figure of merit" for each of the systems according to his need and desire.

One can infer from the foregoing that the future of the talking book seems very much linked to an evolutionary development from the $33\frac{1}{3}$ rpm disc to the $16\frac{2}{3}$ rpm disc in the United States. Even so, there is reason to believe that these changes do not constitute the last time we shall be making basic decisions on the format of the talking book system. It might,

TABLE 3

WEAR CHARACTERISTICS OF THREE DISC SYSTEMS

Type of Disc (RPM)	*No. of Playings*	*Decrease in Intelligibility*	*Decrease in Signal/Noise Ratio*
$33\frac{1}{3}$	25	None	Negligible
	50	None	Negligible
	75	None	Negligible
	100	None	Negligible
$16\frac{2}{3}$	25	None	Negligible
	50	None	Negligible
	75	None	Negligible
	100	None	Slight
$8\frac{1}{3}$	25	Slight	Slight
	50	Noticeable	Noticeable
	75	Significant	Significant
	100	Great	Great

NOTE: Decrease in intelligibility toward center of record, due to reduced linear velocity and increased tracking difficulties, noted with all three systems.

TABLE 4

COST PER HOUR AND PACKING REQUIREMENTS OF THREE DISC TALKING BOOK SYSTEMS

NORMALIZED COST PER HOUR OF RECORDED MATERIAL

Quantity	*$33\frac{1}{3}$ rpm*	*$16\frac{2}{3}$ rpm*	*$8\frac{1}{3}$ rpm*
160	1.1	.73	.46
300	.83	.54	.28
500	.68	.42	.21
1000	.58	.33	.14

These costs are exclusive of containers. In order to take advantage of the cost and bulk savings the books should be packed as follows: (For a 12 hour book)

$33\frac{1}{3}$ rpm	*$16\frac{2}{3}$ rpm*	*$8\frac{1}{3}$ rpm*
1 book per container 12 records (average)	2 books per container 16 records (average)	6 books per container 12 records (average)

TABLE 5

COMPARATIVE STANDING ON ECONOMIC, TECHNICAL, AND HUMAN FACTORS OF THREE DISC TALKING BOOK SYSTEMS

		Factor	
System	*Economic*	*Technical*	*Human*
33⅓ RPM	Index: 100 Most Expensive	Highest quality Longest wear Simplest reproducer in cost and construction	Fully accepted Optimum playing time/side Easily indexed Simplest in operation Greatest bulk Difficult to ship and store
16⅔ RPM	Index: 60–66	Acceptable quality Acceptable wear Cost of reproducer slightly higher than above	Generally accepted Nearly optimum playing time/side Fairly easily indexed Relatively simple in operation Fewer number of records—less bulk Relatively easy to ship and store
8⅓ RPM	Index: 30–45 Depending on quantity and on recording pitch	Initial quality acceptable Very rapid wear Cost of reproducer relatively high (if relatively very high, quality and wear improve)	Resistance to accepting Playing time too great Difficult to index Relatively difficult in operation Fewest number of records—least bulk Easy to store; difficult to ship NOTE: for 7-inch record bulk is reduced.

in fact, be best to reserve decisions on the utilization of magnetic tape, or an 8⅓ rpm disc, or some other medium as yet unconsidered.

It is my considered opinion, however, that the forthcoming 16⅔ rpm disc talking book system has some inherent characteristics that make it highly desirable to the blind user in the United States. I would consider these to be: a) that the system requires only a simple, rugged, and economical reproducer; b) it is an inexpensively duplicated recording; c) it has the virtue of good voice quality and good durability in spite of its lack of complexity.

A few words might be said about the 8⅓ rpm disc system, since this system seems to offer attractive possibilities on the face of the matter; I shall defer the question of the use of magnetic tape to the other papers in this Panel.

The 8⅓ rpm disc is most attractive on the counts of cost (which is very low), compactness (it could be made quite small for the same recording time), and density (yet more information can be recorded on the same size disc as the 10- or 12-inch systems). Viewed in the light of the present state of the art, however, the otherwise attractive possibilities show some serious limitations. A comparatively heavy and definitely more expensive motor/turntable unit is required to meet the demand for a reproducer with less flutter and wow than the present systems can tolerate. A pickup with a high compliance and a minute stylus tip radius is required, and this system must be mounted in a very precise tone arm; this combination alone guarantees that the system will be, relatively speaking, very fragile and easily thrown out of adjustment. Finally, this system has a rather restricted bandwidth even for the speech quality required, and adds to this fault a rather low signal/noise ratio and poor durability.

In short, it is very doubtful that the cost advantage of the 8⅓ rpm system over the 16⅔ rpm system would ever outweigh its shortcomings unless the present state of the art were to be surpassed by perhaps an order of magnitude. I would be willing to crawl out on a limb, in fact, and assert that the 16⅔ rpm disc system will continue to be used from the present time to far into the future.

THE COST ANALYSIS OF THE DISC TALKING BOOK PROGRAM

ROBERT S. BRAY
United States Library of Congress, Washington, D. C.

In considering the cost of our disc talking book in the United States, and in analyzing some of its features, I should like to keep in mind the admonishment of Dr. Scherchen to consider the human factors in the whole picture of which we discuss only a segment; and Mr. Clark's reminder that we are talking about a system. I should like to add to these two premises the thesis that what we are really talking about here is the objective of the program, namely the book. The book is the objective and the system is at best merely occupied in solving what those of us in the library profession refer to as ". . . the general problem of bringing books and people together." No matter how attractive the technology of any device or any system of devices working in series may be, we can never lose sight of this primary objective of "bringing books and people together." Hence our goal, from the point of view of cost, is to bring talking book costs as close to inkprint book costs as possible.

If you consider the paperback book market in this country and elsewhere it is difficult indeed to bring these two sets of costs—of talking books and of inkprint books—into a very close relationship. This is, however, the ultimate goal. Let us assume, instead, that we will consider hard cover books as they are first published, and further, that the average inkprint book will cost $4.50. The goals of the talking book program are phrased in terms of the human conditions by stating the reading needs—the reading interests—of blind persons, the provision of a representative cross section of the annual book publication of the nation, and the provision of these books and magazines with some degree of promptness in an adequate supply.

Let us first consider some statistics which confront us in our task. There are an estimated 355,000 blind persons of whom more than 177,000 are 60 years old or more.* At the moment 65,000, or one-fifth of the total population of blind persons, use the disc talking book service. Each year about 400 titles are issued on discs; about 50 of these are merely re-recordings of titles issued already but which must be replaced because of wear. Against the total of 400 titles which we can offer, we can range the more than 10,000 inkprint titles published annually in English alone. About $750,000 a year is spent for producing the 400 disc titles for the talking book program. Thirty-one regional libraries circulate the books through the mails daily, and they are carried free of charge. Among the 50 states, and on the shelves of the 31 regional libraries, there are about 3000 titles still remaining of the 4500 titles which have been recorded in the past 27 years of the talking book program.

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* These are 1961 figures.

Among our goals we must consider also the following. In contrast to the 400 titles we now offer a year, we could offer 1000 titles without exhausting the popular demand. I believe we could serve 120,000 readers—twice the present number and about one-third of the total blind population.

In the cost of a disc talking book program we must take all of the following factors into consideration: First, the studio time (the "make ready") is constant, regardless of the number of copies produced. You might think that studio time is an expensive item. To my way of thinking this is a justifiable cost for the simple reason that it is in the studio that one has the first chance to achieve quality. Reading which is done by professional persons under excellent technical conditions and expertly monitored will cost money. If one refers back to the human factor, however, perhaps the cost can be justified. Second, the cost of the plastic resin and other compounding material and the two labels, is the smallest item in the total cost. Third, the low cost per unit; this is really nothing more or less than the cost of a copy of a book. A low cost per book is possible when a large number of copies of the book can be made at the same time. If the disc talking book is issued in editions of 350 copies (or more) the unit cost per book is very low; this is the case in the present cost pattern. We will consider a few examples of this structure toward the end of this paper; further details are available from the Division for the Blind of the Library of Congress.

Worth noting is the fact that over the last five years we have been able to order many talking books in an edition of 350 copies or more. This has been possible in part because we obtained a larger budget for books; this enabled us to order larger editions and thus reduce the unit cost. The larger editions were possible in part also because we decided to begin ordering more copies of a given number of titles, rather than few copies of a large number of titles; this constitutes a policy change in the disc talking book program.

A fourth factor in the program is the cost of replacement of discs which are worn and/or damaged. Deterioration due to wear makes the disc a comparatively short-lived storage medium; the cost is amortized, therefore, over a short period of years. At present, we take the year 1955 as the cutoff point; records issued prior to that time are usually so scratched, worn, or otherwise damaged that they must be discarded. If we take the period from 1955 through 1962 the resulting life of the disc talking book collection is thus seven years.

A fifth cost factor is that involving the container. Records are shipped in containers; they are also shelved in containers. In effect each copy of a book is in its container during most of its useful life.

From the point of view of a program, total costs must include those in the purview of the program executive, the individual in charge of the program no matter how great or how small his resources may be. I think there are many similarities in the operation of the program in this country and in other countries. Here the program is free of charge to the user. Because there is no fee or rental charge or other cost to the user, costs are borne by governments at the federal, state, or local levels—or by apportioning costs among all three levels. The implication is that there must be an annual budget for this purpose. We must also supply, in addition, the reproducer on which to play the talking books.

In our own budget, we have to include costs for publications related to talking book production; but that segment provided for talking books is predicated on the number of titles to be recorded each year. If we ask Congress for $750,000 to record about 400 titles, for example, a little arithmetic will show that the average cost is somewhat less than $2000 per title. This "average" is only a convenient fiction, of course, because there is no such thing as a book of "average" length.

The executive administering the talking book program must necessarily maneuver within the costs established by the recording studios, and he is limited in how many out of the almost infinite variety of books published he can choose to include. Any saving he can realize from one portion of the program he can apply toward obtaining a larger number of copies of a certain title and thus reduce the waiting time for the publication of the title. A rather dramatic example of this shifting in the recent past might interest you. The book entitled *The Rise and Fall of the Third Reich* by William Schirer was a "best seller."

Now in any cost accounting scheme the first step is to obtain an estimate of costs; this is particularly true in the case of discs. We must know how much it will cost for X, Y, or Z copies of the book. It happened in this particular case that the estimate obtained from the suppliers of the discs was high; thus the invoice for this production run was lower than anticipated and we were able to order more copies of the book than we originally expected. We bought 500 copies of this book eventually for $25,000 or $50 per copy. A paperback edition of the book costs $1.95 per copy. There is quite a wide gap between the cost of the disc recorded book and the cost of the inkprint edition of the book.

Let us now examine some specific examples of costs for two or three types of disc talking books. A 12-hour book is assumed. In the disc program, as in the tape program, books must be considered in terms of the number of hours of reading involved. In the 33⅓ rpm edition, a 12-hour book in 400 copies costs approximately $11 per copy—or $4400 for 400 copies. We are currently producing books at about this cost level.

For the 16⅔ rpm edition (issued in limited quantities at present but which will become the standard format within seven months), the same 12-hour book contained on 10-inch discs requires a total of 8 discs, and the cost is $7.12 per copy. You will recall that the cost of the normal inkprint book is about $4.50; the cost of this talking book edition is $7.12—or less than twice as expensive, and becoming closer to the price of the original inkprint edition. Four hundred copies will thus cost about $2800. If we can eventually produce only 16⅔ rpm discs and place our orders for just a few additional titles, and for just a few additional copies, we will achieve what is known (in our private circles) as a "50 cent record." Two or three years ago we thought we were being overly optimistic when we talked about a "dollar record," but in fact we are now very close to the 50 cent record. The same 12-hour book on the 50 cent record will cost only $4.85 per copy, which is very close to the previous figure of $4.50 for the inkprint edition. Four hundred copies of the book would then cost only $1900.

These figures are equally attractive in the case of magazines. Consider the monthly magazine of selections from the *Ellery Queen Mystery Magazine,* which is requested by many blind readers. This periodical represents the kind of recreational reading that our program is designed to provide. On the 50 cent, 16⅔ rpm record, one copy would cost $2.35. A year's subscription to the magazine would cost $28.20.

Let us now consider the cost for a 12-hour book, first on discs and then on tape. The tape will be that available on the market now and not depending on any specialized technology. The 12-hour book on 16⅔ rpm discs will cost $7.12, including the container. The same 12-hour book on conventional magnetic tape will require four reels and will cost $9.44; to this must be added the investment in a container or wrapper for shipment and storage of the book.

I can anticipate some of the discussion to follow regarding tape, and perhaps clarify the present discussion, by saying that we have at the moment in this country not only a large and successful disc talking book program in which cost per book is diminishing, but also the beginnings of a tape program as well. About a thousand books are already recorded on conventional tape. The tape talking book program costs very little at the moment because first, we do not provide the blind reader with a tape reproducer, and second, the recording is done by volunteers.

In closing this discussion, I would like to stress the lack of demonstration of two current theses—and the reasons why we continue to look closely at the several variables which are elements of the costs of a disc talking book program. First, there is no conclusive evidence that in a program of the magnitude of our own, a disc talking book program would be displaced by a tape talking book program. This is a challenge to us at the moment. Tape development is not as mature as that of disc development in this country in terms of acceptance, in terms of technology, and in terms of the administration of the production and distribution system. Second, we should remember that the nature of progress is evolutionary, not only with respect to library materials but in many aspects of business and of the professions: we increase our resources rather than decrease them. This is the reason why we may eventually have tape talking books as one more resource available to the reader rather than as a system which will replace the disc system now in use.

THE BRITISH TAPE CASSETTE SYSTEM

H. J. F. ADAM
Royal National Institute for the Blind, London, England

INTRODUCTION

It is an honor and a privilege to have been selected to present to you the British tape cassette system—although this is perhaps now a misnomer since, though it was devised in Britain, it is already operational in Australia, New Zealand, Spain, South Africa, and Rhodesia and will within the next few weeks be installed in the Argentine and Canada.

This system was developed by the Royal National Institute for the Blind and St. Dunstan's over a period of many years. It had long been felt that the disc talking book had many inherent disadvantages: rapid deterioration of quality, storage problems, the need for inspection of each disc on return from the reader, constant replacement of styli, and the need to estimate in advance the number of copies required. These and many other factors prompted an intensive investigation into some alternative form of recorded books.

On the assumption that tape was the only feasible alternative, certain basic principles were kept constantly in mind:

1. It should be extremely simple in operation.
2. There should be *no* exposed tape.
3. No tape loading by the blind reader should be necessary.
4. It should be impossible for the tape to be pulled off the spool.
5. It should be of sturdy construction without being cumbersome.
6. It should be possible for libraries large or small to produce recordings quickly, simply, and in quantity, as and when required.

No domestic tape machine meets these essential requirements, but I feel that in the British tape cassette system all have been met.

Once a prototype reproducer and cassette had been proved, a 12-month field test was carried out (see Table 1).

One hundred blind readers of all types were issued machines, and 300 recorded cassettes were put into circulation. At the end of the year a ques-

TABLE 1

READER PREFERENCE FOR BOOKS OF VARIOUS DURATIONS

Hours of Playing Time		*Percent of Requests*	*Cumulative Percentage of Requests*
less than	*to*		
2.5		1.5	0.5
2.5	5.0	4.3	5.8
5.0	7.5	24.1	29.9
7.5	10.0	25.8	55.7
10.0	12.5	15.7	71.4
12.5	15.0	9.1	80.5
15.0	17.5	5.8	86.3
17.5	20.0	4.6	90.9
20.0	25.0	6.9	97.8
25.0	30.0	1.2	99.0
30.0	40.0	0.7	99.7
Over 40.0		0.3	100.0

tionnaire was distributed. The result was really quite astonishing. Ninety-seven readers preferred this system to the disc system on every count, but particularly because of its extreme simplicity of operation. Of the remaining three readers, one preferred the disc system (but gave no reasons) and two preferred the tape but with reservations. With this considerable encouragement we went into full production.

THE TAPE CASSETTE

It is the cassette which is the novel, indeed the revolutionary part of this system. It contains up to 21 hours of recorded material—enough for two average books, and certainly enough for all but the very longest ones.

Unlike the domestic tape recorder which uses two or four tracks on one-quarter inch tape, the cassette uses one-half inch tape having 18 separate recorded tracks, each of up to one hour and ten minutes duration.

The metal shell of the cassette is a strong protective cover for the entire tape, spool, and replay head assembly. This means that the tape is completely enclosed and it is impossible for it to be touched or handled in any way by the reader. Not only does this eliminate all the complications of tape loading by the reader but it makes any damage to the tape almost an impossibility. Thus the original quality of the recording will be retained almost indefinitely.

The tape is loaded at the library onto two superimposed reels and when the cassette is first placed on the reproducer all the tape is on the top spool. The driving spindle causes the tape to be taken up on the bottom spool and in so doing it passes the replay head. Brakes are provided so that the spools are locked until the cassette is actually on the reproducer. Thus all risk of tape spill is eliminated. The track change is controlled by a push button and a sprocket. Each time the button is pressed the replay head moves through one of 18 positions (see Figure 1).

THE STANDARD REPRODUCER

Figure 2 shows the standard reproducer as issued to our blind readers. It is rented to the blind reader for £2 ($5.60) per year and no other charge

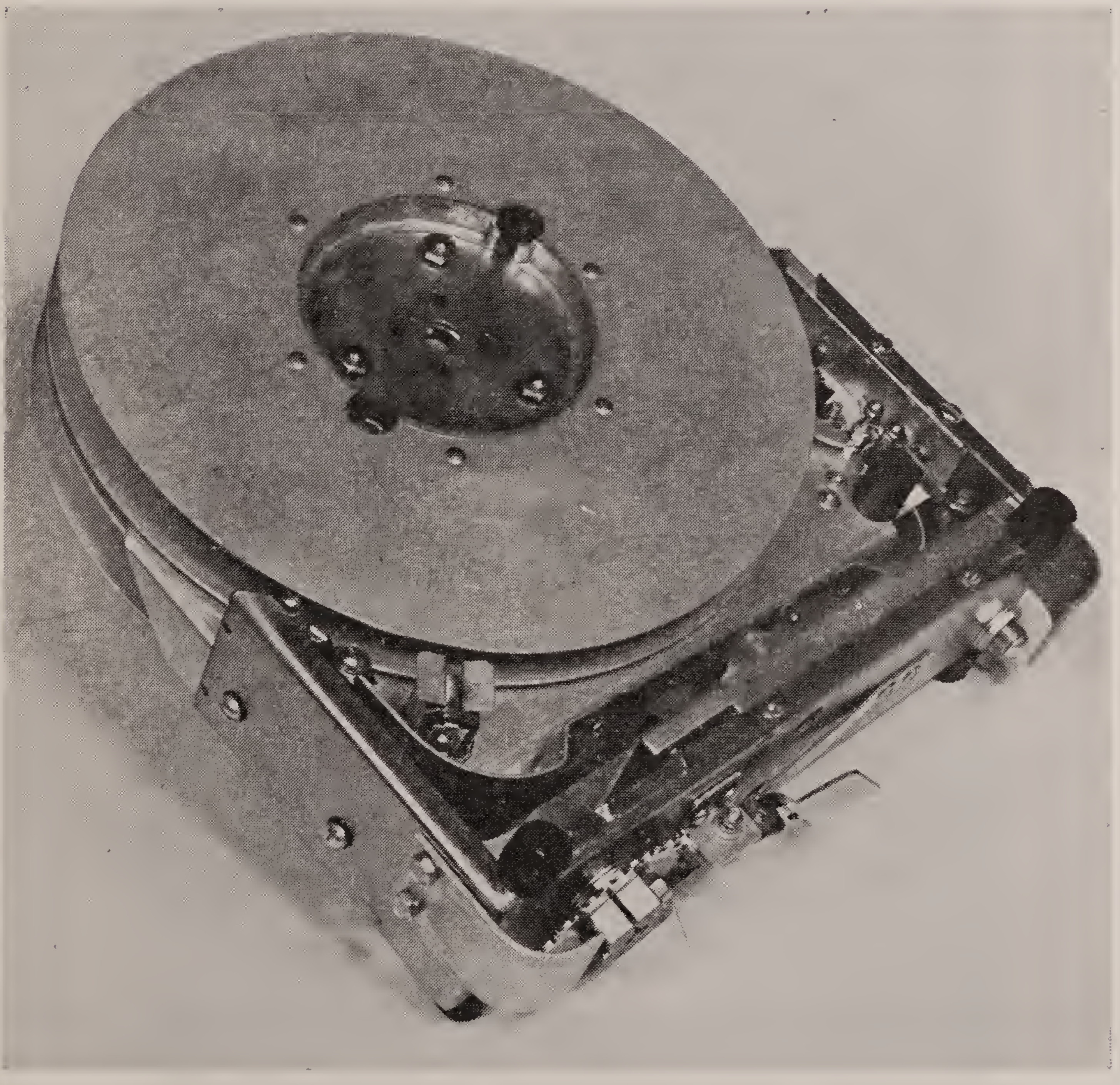

FIGURE 1 British Tape Cassette. (The illustration shows the cassette with its cover removed.)

is made. The machine is extremely simple, having only three controls—an ON/OFF volume control, a tone control, and a START/STOP switch. A jack is provided so that headphones may be used, in which case the loudspeaker is muted. On the playing deck is a driving spindle which revolves at 15 rpm and at the rear are two rounded locating shoulders. The reader has merely to switch on the machine, place the rounded part of the cassette against the shoulders on the reproducer, and lower it onto the deck. When the start switch is operated the drive spindle will automatically engage. At the end of each track an announcement is made, followed by a high-pitched tone of 4 kc/sec which causes the drive to be automatically switched off. Thus if the reader has perhaps fallen asleep or been called away, the tape cannot be pulled off the spool. But in the unlikely event of

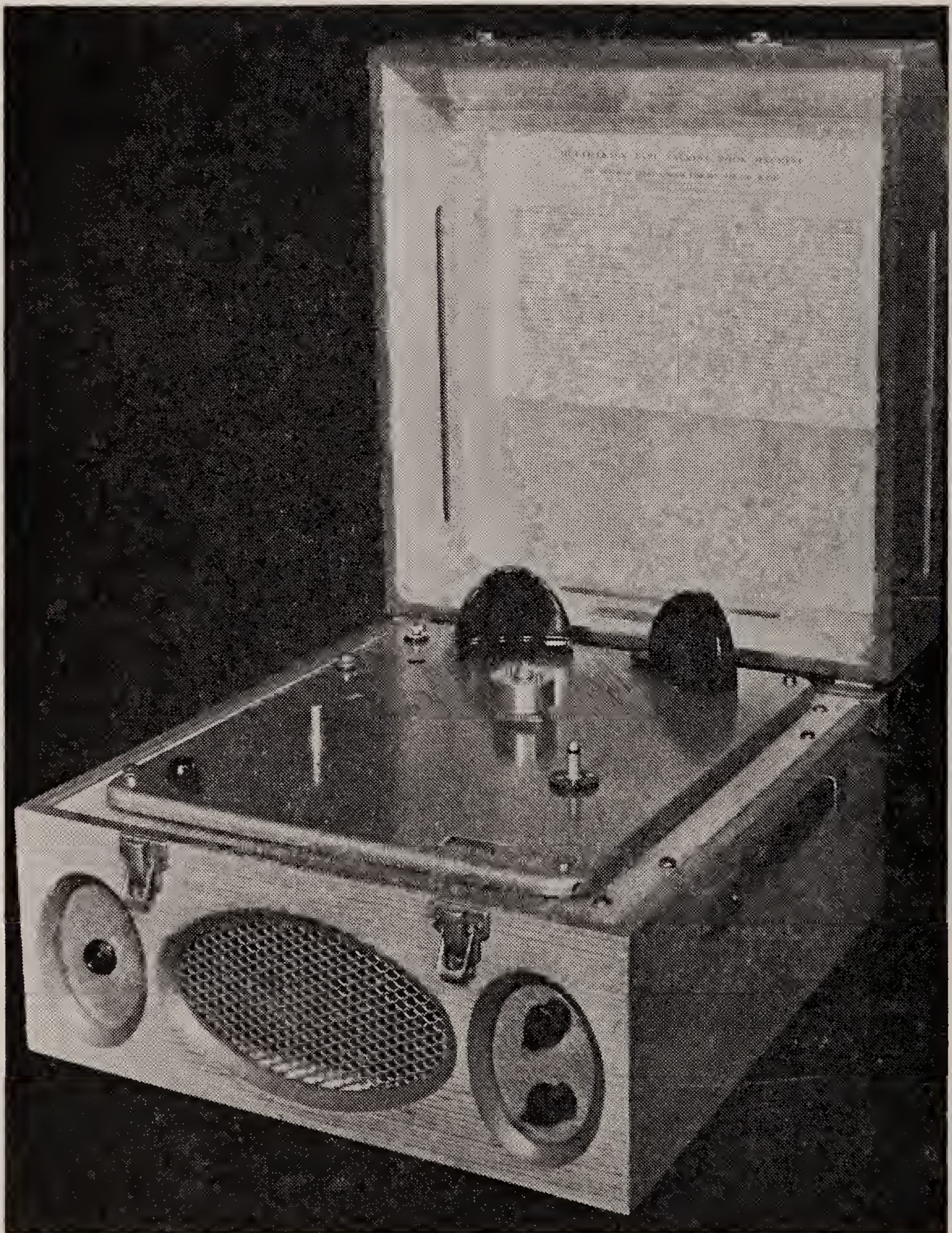

FIGURE 2 The Standard British Tape Cassette Reproducer

this failing to function, an additional precaution has been built in, in the form of a 'slipping clutch' on the drive spindle.

So much for the standard reproducer and cassette.

MODIFICATIONS TO THE STANDARD REPRODUCER

Considerable thought has been given to making this system particularly suitable for *student* use and also to make it more easily used by rheumatic, arthritic or even handless blind readers, or by the elderly blind, and as a result certain optional accessories have been devised (see Figure 3).

A rotating cage is provided in the lid of the machine into which the cassette is loaded. The cage is so designed that the cassette cannot be

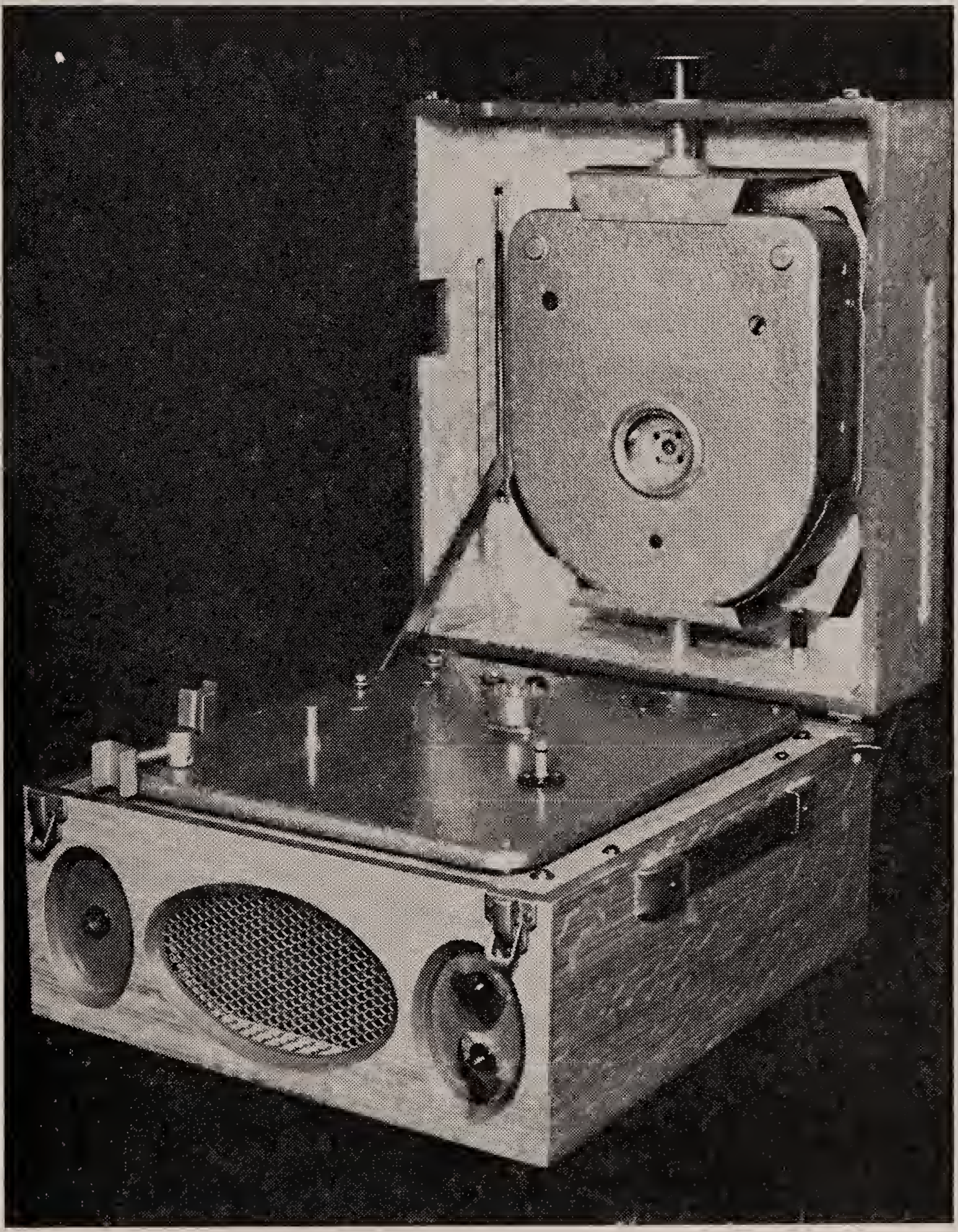

FIGURE 3 Modified Standard British Tape Cassette Reproducer

wrongly positioned. In the case of the additionally handicapped reader this loading might have to be done for him.

The lid of the machine is spring loaded so that a minimum of strength is required to operate it. Any slight pressure allows the lid to be lowered and in so doing the cassette automatically engages the drive spindle. The START/STOP lever has been extended and here again only a gentle movement is needed to operate it.

At the end of the track the 4 kc/sec note will switch off the drive. The lid is raised—if necessary using the forearm rather than the hands—and the cage turned. The lid is lowered and the track change button, now extended to the front of the lid, is pressed. Switch to start, and the next track plays.

For student use, a speedy means of back reference is obviously essential. By the provision of a slot immediately above the track change sprocket one can rapidly select any track desired. If one wishes to listen to, say, track three, all that is necessary is to press the button resetting to track one, then press the button the appropriate number of times. Thus we have almost immediate access to any one-eighteenth part of a book.

By means of a fast rewind attachment which can be easily and quickly fitted to any reproducer it is possible to rapidly locate any part within that track. The facility therefore exists to go easily and quickly to any predetermined part of a 21-hour book. This facility I think compares very favorably with anything in the commercial field today. A number of methods of indexing within tracks are being investigated but so far no final decision has been made, though a number of methods are possible.

THE SPECIAL COPYING MACHINE

I have so far described to you a reproducer and tape cassette which despite its extreme simplicity offers quite surprising facilities for the blind reader.

We now come to the question of quantity production of recorded cassettes. The original master recordings for this system are made on standard two track one-quarter inch tape at a speed of $3\frac{3}{4}$ in./sec. We already have some 800 recorded and are producing about 150 new titles each year. These master recordings are placed onto a copying machine (see Figure 4). This piece of equipment is quite original in conception and design, and developed in the laboratories of the RNIB. Twelve cassettes, loaded with the requisite amount of tape for the recording time required, are loaded on to the 12 spindles of the copying machine.

The operator now has the facility of copying from the master tape to the

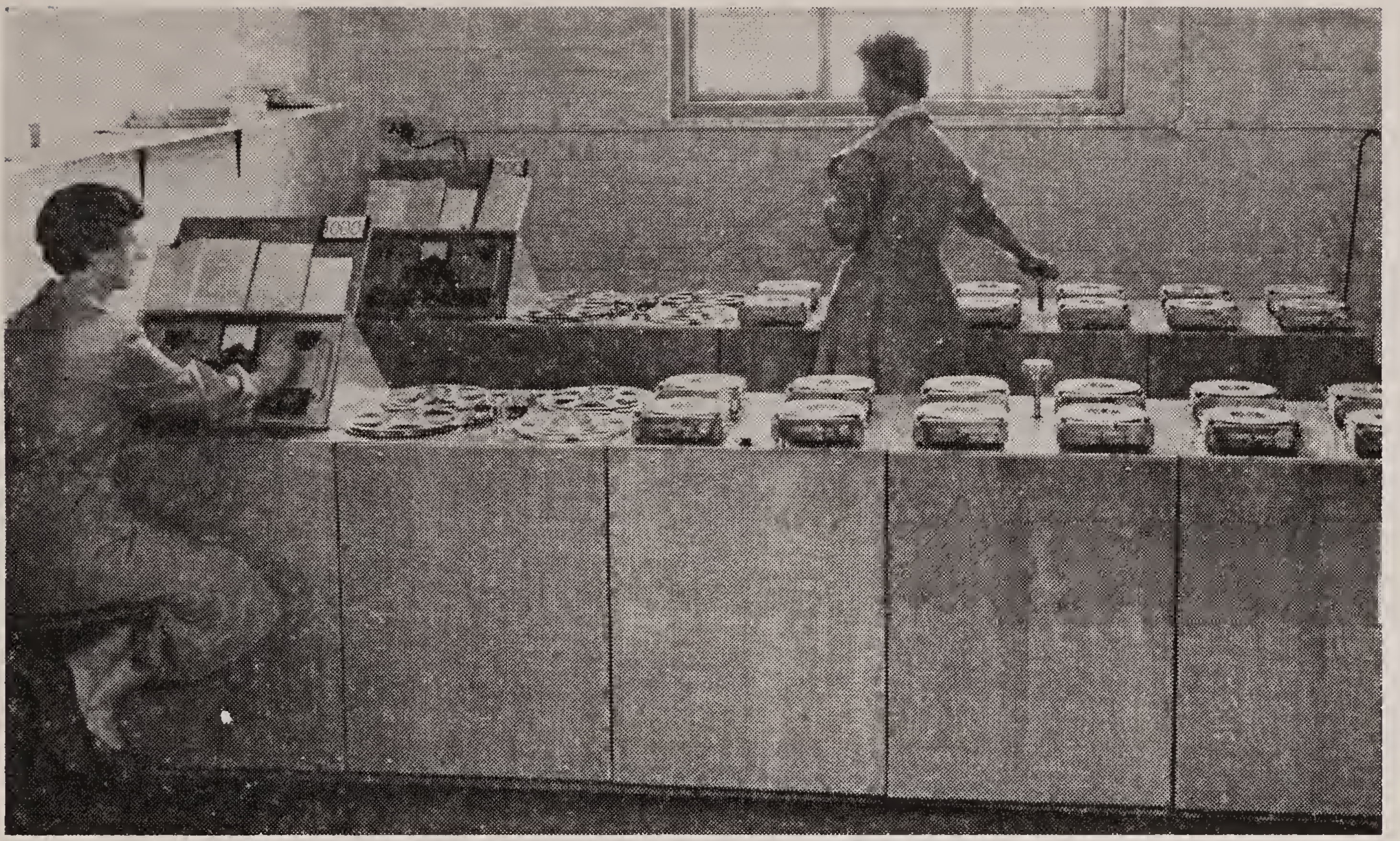

FIGURE 4 Tape Copier for the British Tape Cassette System

cassette at six times normal reading speed, editing the book into 18 roughly equal parts during the process. The second master tape on the deck is a recording of track beginnings and endings and simple switching on the control unit enables either tape to be brought in when required.

The 12 recorded cassettes, produced in little more than one-sixth of the time it would take to read one, are put into their metal shells and then into a postal container and placed on the library shelves—available to the library members just a few hours after the original recording of the book was completed. Should further copies be required, no further editing is needed. One of the cassettes already recorded is now used as the master and a straight six-to-one speed copying operation is all that is needed.

The copier can also serve as a rewind machine. Cassettes returned to the library need merely be placed on the spindles and are rewound 12 at a time, to the beginning of the book, in a single high speed operation. It can also be used for the initial loading of the cassettes with blank tape, for the required quantity can be calculated quite accurately to fit the length of the book to be copied and thus eliminate tape wastage. The length can be estimated to within 50 feet. Only 1500 feet of one-half-inch tape is required for a 21-hour book.

The operator need not be highly technically qualified. All that is needed is a certain manual dexterity and common sense. After only a few days of instruction operators become confident and efficient.

It will be seen, then, that having produced the master recording, copies may be produced rapidly on short notice to meet the requirements of the moment. This system is ideal for small editions. If the demand has been underestimated further copies can quickly be made, thus obviating a large initial stock of copies (as was usually the case with disc) and easing the library storage problem. This in turn means that a large number of titles can be stocked.

It is equally ideal for large editions. Heavy initial demand for a popular book can be satisfied without the risk of carrying a big stock which will lie idle on the library shelves after the first rush of requests has subsided. Redundant recordings can be bulk erased and the cassettes re-recorded with new titles.

The machine may be used in any room with a domestic power outlet. No soundproofing or special preparation is needed.

While it is desirable to have a competent technician in over-all charge, the actual operation of equipment at the library can be carried out with comparatively unskilled labor.

DISCUSSION

One of the great advantages of this scheme is its eminent suitability for all types of talking book libraries, large or small. Production of recorded cassettes is simple, speedy, and entirely within the control of the library, which can produce an infinite variety of books to suit local taste. By the interchange of cassettes with other countries using this system, the whole field of recorded foreign literature can be made available to the blind reader in Boston, Bristol, or Barcelona. It is not necessary for the operator to know the language in which the recording is made since all the necessary editing will have been completed at the library of origin.

The initial cost of installing the basic equipment is extremely modest and well within the reach of most organizations for the blind. The major item—the copying machine—costs only £797 ($2232) and, having installed such a basic unit, expansion is a simple matter and can be adjusted to suit the finances available. Several organizations are starting with as little as 50 reproducers and 150 cassettes and adding to this number month by month.

Any relatively small library, serving from a few hundred up to two or three thousand readers could function quite efficiently using one 12-spindle copying machine, but a conservative estimate of the production capability in a five-day week, using two copiers, would be as follows: With the first copier fully occupied copying cassettes from original master tapes, production would be about 12 or 13 titles per week on 150 to 160 cassettes. The second copier would be used to produce additional copies from a master cassette selected from the first run and would produce about 200 to 240 copies per week. This gives a total weekly production of 350 to 400 cassettes per week.

It is estimated that to maintain a satisfactory turnover of books—considering that some are with the reader, some in transit, and some on the library shelves—a ratio of three cassettes to each reproducer is needed. Therefore it will be seen that a library with two copying machines could serve between 116 and 133 new readers each week or something over 6000 new readers each year.

Before readers are issued with machines it would of course be necessary to build up a basic library stock of recorded titles, which would be available immediately the scheme became operational. Here an interchange of master cassettes between organizations operating the scheme would be invaluable.

In Britain, in order that considerable stocks of disc machines should not become obsolete, a gradual change-over is taking place. The new tape machine is being issued to those readers who have read all or nearly all the disc titles available. The disc machine is withdrawn, overhauled, and reissued to a new reader who still has the whole of the disc library at his disposal. About 25 percent of all disc machines recalled are scrapped. When all existing members have been issued with the new tape machine no further disc issues will be made and the change-over will then be complete. I anticipate that this will be within two to three years (i.e., by the end of 1964 or 1965).

As a result of an appeal which we made through various technical journals we now have a panel of several thousand volunteer helpers throughout the country who, when the machine is issued to a new reader, undertake to visit him and instruct him in its use and ensure correct installation. If at any time the reader needs help with his machine he contacts his local volunteer helper who goes to the reader's home and does whatever might be necessary.

After nearly two years of operation we in Britain and, what is more important, our blind readers are delighted and completely satisfied with the new tape system. We feel that with this cassette system we can offer a simple, reliable, and flexible service which because of its simplicity of cassette interchangeability and its eminent suitability for all types of libraries, might well be considered as a standardized talking book service—not only in those countries already operating this scheme, but indeed throughout the world.

APPENDIX: MAGNETIC TAPE TALKING BOOKS NOTES ON OPTIMUM PLAYING TIME OF THE CASSETTE

Introduction. The present maximum playing time—21 hours per cassette—was chosen largely so that most titles could be accommodated in a single cassette. It has often been pointed out that this choice means that many cassettes are being used to much less than their full capacity. Shortening the playing time of the standard cassette would reduce its size and weight which might lead to greater ease of handling by the blind reader, less space required for storage in the library, perhaps to some easement of the transport problem, and to some saving in cost.

At present, only a very minor proportion of books require more than one cassette. Reducing the playing time would obviously increase this proportion—a disadvantage which would have to be set against any advantages gained in other directions.

To obtain data to help in deciding whether or not to make such a change, an analysis was made of all the requests for loans handled by the library during the year 1 January 1960—31 December 1960. These relate only to disc recordings since these cover by far the most comprehensive range of titles at present, but there is no reason to suppose that the conclusions drawn would be very different if the same range had been available on tape. The analysis covered about five hundred titles, all recorded at 24 rpm.

Analysis of Recent Loans. The number of discs required for each title was converted to playing time on the assumption that one disc corresponds to 50 minutes.

Each title was placed by the library in one of eight groups according to the total number of requests received for it during the year viz:—under 100,100-200, . . . , 600-700, over 700. Each title was then given a weighting factor of 1 to 8, according to the group in which it appeared. The titles were then regrouped to bring all books of the same length together. Adding up the weightings for each title in one of the new groups then gave a measure of the over-all popularity of books of that particular length. These figures were worked out for about 40 different lengths of book and converted to percentages of the total demand. For simplicity in presentation, the figures have been lumped together in 12 ranges of playing time as shown in Table 1. The median value is at about nine hours and the very long books clearly represent a very small percentage of the total demand.

Design of Cassettes of Alternative Playing Times. It can be shown readily that in any cassette using this principle of tape drive (i.e., constant spindle speed, variable tape velocity) the most efficient use of tape is obtained when the outside diameter of the coil of tape is exactly twice the core diameter of the coil. In considering alternative playing times it was assumed that all cassettes would be designed on this basis which, incidentally, is closely approximated in the present cassette. The present minimum linear tape velocity is 2.94 in./sec. This is certainly unnecessarily high for present standards of quality of talking book reproduction with modern reproducing heads but, to facilitate comparison with the present cassette, it is assumed that this feature would be retained in its alternative and the spindle speed is chosen to give this for each example. In reality, if more than minor modifications were made to the present design, the tape velocity would almost certainly be reduced; but it should be fairly easy to allow for such changes in interpreting the results which follow.

To facilitate comparison further with present practice, it was assumed that one-half inch wide tape with 18 tracks would be used. As will be seen later, this may or may not be the best choice. The thickness of the alternative cassettes has therefore been assumed to be the same as at present and the length of the cassettes has been assumed to be 2 inches greater than the width to accommodate the track changing mechanism. The width of a cassette has been taken as one-half inch greater than the o.d. of the spools which, in turn, has been taken to be one-half inch greater than the o.d. of the tape coil. The dimensions of the postal container were arrived at by assuming three-fourths inch thickness (of packing and container wall) round the edges and one-half inch at top and bottom.

Costs are difficult to estimate. Since the mechanism will be virtually the same throughout, it is unlikely that the cost of the smallest size of cassette will be less than about 90 percent of the cost of the present cassette. The postal container offers more scope for economy, and it was assumed that the smallest size could be produced for about 60 percent of the cost of the proposed new design.

Some of the more important features of various arbitrary sizes of cassette based on the foregoing assumption, and some of the likely effects of their adoption on the library service, are shown in Table 2.

Discussion. It is evident that cassettes of playing time less than six hours are undesirable from considerations of cost, storage/space requirements, and the relatively large number of loans which would need more than one cassette.

There are indications of rather shallow minima in both cost and storage requirements for playing times of 12 to 16 hours. For these, also, a high proportion of loans would require only one cassette and practically all would require only two cassettes. This suggests that the ideal playing time is somewhere in this range—the actual figure depending on the importance attached to the desideratum of one cassette per title. The flatness of the minima is, however, important: there is obviously little to be gained by more accurate attempts at assessment than has been possible in these notes.

The figures in Table 2 indicate that the present size of the cassette is not ideal. The trends in the range 12 to 24 hours are so gradual, however, that there appears to be no practical justification for departing from this size as long as the present principle of operation is retained.

It should be emphasized that the most important factor in this discussion is

TABLE 2

DESIGN FEATURES OF VARIOUS SIZES OF 18 TRACK TAPE CASSETTE: EFFECTS ON LIBRARY SERVICE

Feature	*Playing Time of Cassette (Hour)*								
	1	2	4	6	8	12	16	20	24
Core diameter of spool (inches)	0.75	1.21	1.50	1.84	2.12	2.59	3.00	3.35	3.68
Maximum diameter of coil of tape (inches)	1.50	2.42	3.00	3.68	4.24	5.18	6.00	6.70	7.35
o.d. of spool, approx. (inches)	2.00	2.90	3.50	4.00	4.75	5.70	6.50	7.20	7.90
Width of cassette (inches)	2.50	3.40	4.00	4.50	5.25	6.20	7.00	7.70	8.40
Length of cassette (inches)	4.50	5.40	6.00	6.50	7.25	8.20	9.00	9.70	10.40
Volume of cassette only (cubic inches)	23	37	48	59	76	102	126	149	175
Volume of cassette in postal container (cubic inches)	72	101	124	144	177	224	268	309	353
Approx. average total bulk of cassettes in containers per copy per title (cubic inches)	860	625	415	350	340	310	315	340	370
Spindle speed (rpm)	75.0	53.0	37.5	30.6	26.5	21.6	18.75	16.8	15.3
Approx. length of tape (feet)	75	150	300	450	600	900	1200	1500	1800
Approx. cost of tape (£)	0.125	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0
Approx. cost of tape ($)	.35	.70	1.40	2.10	2.80	4.20	5.60	7.00	8.40
Estimated cost of 1 cassette plus tape plus postal container (£)	5.8	6.0	6.4	6.8	7.2	7.8	8.4	9.0	9.7
Estimated cost of 1 cassette plus tape plus postal container ($)	16.28	16.80	17.92	19.04	20.16	21.84	23.52	25.20	27.16
Estimated cost of cassettes, tape and containers per copy per title (£)	68	37	21	16	14	10.7	9.9	9.9	10.1
Estimated cost of cassettes, tape and containers per copy per title ($)	190.40	103.60	58.80	44.80	39.20	29.96	27.72	27.72	28.28
Percent of requests satisfied by n cassettes per title									
n = 1 cassette	0.2	0.5	3.9	9.3	30	67	83	91	95
n = 2 cassettes	0.5	3.5	30	67	83	95	99	100	100
n = 3 cassettes	1.5	9.3	67	86	95	99	100	100	100
n = 4 cassettes	3.9	30	83	95	99	100	100	100	100

that of reader preference. Even if circumstances should justify a major change of design at some future date, the ideal playing time will remain in the range of 12 to 16 hours, unless there is a marked change either in the reading habits of users or in the policy of keeping down the number of cassettes per title.

Policy for Future Development. If it is agreed that this argument disposes of any real urgency to consider basic modification in the present system, it must be expected that service experience will reveal various detailed defects from time to time and these, of course, must be eliminated. This process should make only relatively minor demands on development effort. Technological improvements in sound recording and reproduction will, however, undoubtedly continue to emerge and in due course these will have the effect of making the present system obsolete. It is obviously prudent to make plans now against this condition. It is suggested that the major part of such development effort as can be spared should therefore be devoted to the development of a Mark II system.

This Mark II system, whose introduction might be envisaged in, say, five to ten years time, might well be compatible with the present system, but this desideratum should not be applied in a rigidly restrictive manner. Still less should the Mark II system be regarded merely as an improvement of the present Mark I system. It should be regarded as a complete substitute, ultimately, for the Mark I, and the approach to its development should be based firmly on that expectation. Complete rethinking, even to the extent of accepting the possible emergence of some radically new and better principle of sound recording, should be regarded as permissible, and work on the new system should be allowed to proceed without undue emphasis on urgency.

Possibilities for Future Development of the Magnetic Tape System. On the assumption that future developments will continue along the line of use of magnetic tape, it is possible to make some useful deductions from the results of the present study.

First, it is now possible to make some quantitative comment on the old controversy of constant tape velocity vs. constant spindle speed. For cassettes of 4 and 12 hours playing time, the cost of the tape is respectively 8 percent and 19 percent of the total cost of the cassette and postal container. Assuming ideal design proportions, the constant spindle speed system requires 50 percent more tape than does the constant tape velocity system for the same playing time. The savings in the total cost of the cassette, etc., which would result from the more economical use of tape in the latter would therefore amount to only 3 percent and 6 percent respectively. If the minimum tape velocity were reduced only by a factor of two (and a greater reduction is thought to be practicable), the savings on cost of tape would be only $1\frac{1}{2}$ percent and 3 percent. Against these savings, the mechanism required for constant tape velocity would be somewhat more complicated and therefore more costly. A change to the constant tape velocity system would therefore appear in itself to be quite unjustified unless it confers substantial advantages in directions other than cost.

Since the volume occupied by the tape alone is only a small fraction of the total bulk of the cassette in its postal container, similar arguments show that a change of driving system is not justified on the grounds of saving of space.

As mentioned earlier, a reduction in tape velocity should certainly be possible using modern narrow gap heads, and an applicable reduction factor might be two, three, or even four. A 12- to 14-hour cassette might thus be expected to have characteristics similar to those listed in Table 2 for a four-hour cassette, i.e., a reduction of 50 percent on bulk and 20 percent on cost compared with the hypothetical 12-hour cassette; 60 percent on bulk and 40 percent on cost as compared with the present standard cassette. It must be remembered, however, that considerable work would have to be done to prove such a cassette which is reliable in practice, and there can be no hope of its early introduction.

One possibly important difficulty in developing a slower speed cassette along these lines, which can hardly be assessed without direct experiment, is that of maintaining the correct track/head relationship. This difficulty would tend to be enhanced by greater variations in azimuth which would be inherent in the use of a geometrically smaller cassette. At the lower limit, it might even turn out to be necessary to use a different form of track selector mechanism.

It may be remembered that the use of side-by-side spools was rejected in favor of superimposed spools; an engineering report from the Chief Engineer, No. CI-615C, presented on 29 January 1957, explores this decision. The factors which led to that decision may not apply to the much smaller spools which reduced tape speed and playing time together permit. This question should therefore be re-examined if only because the side-by-side arrangement might permit such a reduction in over-all thickness of the cassette, and therefore of the postal container, that cassettes could be posted back to the library via an ordinary pillar box instead of having to be taken to a post office.

A different approach may be useful, particularly if it proves to be unexpectedly difficult to maintain azimuth with narrow gap heads. This involves work on narrower tape, with a much reduced number of tracks, and with multitrack heads. Thus, we might have four tracks on a standard one-quarter inch wide tape, and reproduce this by means of a two track head which would need merely to slide from one fixed position to another to reproduce the four tracks (alternatively, two fixed two track heads could be used). The cost of an additional head would probably be more than offset by the saving from the elimination of all track selecting mechanisms. It might in fact be economically and mechanically practicable to use a coupled pair of two track heads with two alternative working positions, or a fixed group of three or four two track heads. No attempt has been made to work out the implications of these suggestions in detail—first because some experimental work would probably be necessary before cereain essential features could reliably be assessed, and second because these suggestions are only a few of the possibilities which merit serious consideration. It may, however, be pointed out that 1500 feet of four track recording, 1000 feet of six track recording, or 750 feet of eight track recording (all one-quarter inch wide) would lead to a playing time at $\frac{15}{16}$ in./sec of about 14 hours per cassette, which is long enough to cover about 75 percent of requests with a single cassette.

Finally, it may be opportune to offer a few comments on the use of endless loops of tape. The attractions of such a system are very great, but no wholly successful long playing arrangement has yet been devised. Practically all the defects of poor performance due to stretching of the tape, or of actual tape breakage, are caused by the relatively large forces necessary to overcome friction as the turns of tape slip over each other. In many instances the situation is aggravated by the aim to use tape speeds high enough for the reproduction of music—a very different requirement from that of speeds only high enough to properly reproduce speech—especially if we take full advantage of the possible reductions in tape velocity. Even then, it would be unlikely that the need for inter-turn lubrication would be avoided. Liquid lubricants have been tried for this purpose; they tend to be effective for a time, and then become gummy and so create a situation worse than the absence of lubrication. For our purpose the use of solid lubricants might be more attractive. In fact, the tape might be pretreated by running it over a suitably shaped block of polytetrafluorethylene (PTFE), and adequate lubrication could perhaps be maintained in service by the simple expedient of making the tape guides out of the same material. Recent developments in the plastics field suggest that it may even be practicable to use PTFE itself for the tape base, which would give an inherently low friction material. At present, these suggestions are purely speculative but, with so many potential advantages, might merit serious consideration.

THE TAPE CASSETTE SYSTEM PROPOSED BY THE LIBRARY OF CONGRESS

ALFRED KORB
United States Library of Congress, Washington, D. C.

It was with a sense of great admiration, and a revelation to me, to have seen what Mr. Adam and his colleagues have actually produced. Knowing how much work was done and with what great ingenuity it was done, we are to my way of thinking only in the experimental and embryonic stage of development of a tape cassette system.

INTRODUCTION

In the United States, the introduction of the medium of tape to supplement the talking book on discs was initiated several years ago by the Library of Congress (3). At the time Mr. Bray took office we were just beginning to discuss the possibility of books on tape. In the last five years, a feasibility and application study conducted by Cook Research Laboratories has recommended the utilization of a tape based talking book system, and has developed several designs for a suitable tape recorder for this purpose (1).

The implementation of a tape talking book system for a nationwide program such as ours involves many different facets of operation, for we must provide various forms of reading material to approximately 65,000 visually handicapped readers. In the United States there is an estimated potential of 360,000 legally blind persons who are entitled to participate in the talking book program. The recorded books are distributed to the visually handicapped by 31 regional libraries through a catalog mail order type of circulation service.

The objective of this paper is to present one practical and feasible tape based talking book system which could reflect advantages to the user, promote more effective library service, achieve greater economy, and provide for future needs of an increased number of readers.

The operation of the proposed talking book system is as follows:

1. The staff of the Library of Congress select the titles of the books (as at present).
2. Professional readers record the books on a studio recorder (as at present).
3. The Master Tape is then re-recorded onto an Intermediate Master.
4. Multiple copies of the Intermediate Masters of each title are duplicated at high speed from the original. These might be termed Library Submasters and are recorded for playback at 7½ in./sec.
5. The Intermediate or Library Submasters are used to duplicate at high speed any required number of copies of books. The tape copies will be four track; will play at 1⅞ in./sec; will use one-quarter inch width tape; and will be assembled into cassettes.
6. The cassettes will be circulated through the mail to the user by the regional libraries.
7. When the book cassettes are returned to the libraries, they may be placed on shelves, or they may be erased and reused.

There are two organizational structures which can be utilized in carrying out these operations. One is centralized; one is decentralized. The centralized system is characteristic of the present operation of the American Foundation for the Blind (AFB) and the American Printing House for the Blind (APH) in producing disc talking books. These two organizations carry out the entire operation, from recording the titles onto Master Tapes, to the shipment of book copies to the 31 regional libraries. The decentralized system would perform all or any part of the portion of operation in selected geographical locations throughout the country. Thus upon request a local sound studio could duplicate copies of tape books from Library Submasters (see Figure 1).

In all probability both structures would be used and operate in a complementary manner. Indeed, a combination of both systems is required to realize the maximum advantage to be derived from the versatility of the tape medium.

Centralized recording systems are necessarily limited by cost considerations to the production of books. Reproduction in any medium of a number of periodicals is very costly. Monthly and weekly magazines, popular alike with the sighted and the visually impaired, are, however, prohibitive to reproduce with a centralized system. We had contemplated a monthly magazine in talking book form—until we found the cost would be $25,000 a year. A weekly magazine would cost roughly $75,000 a year. A daily newspaper would break our annual budget!

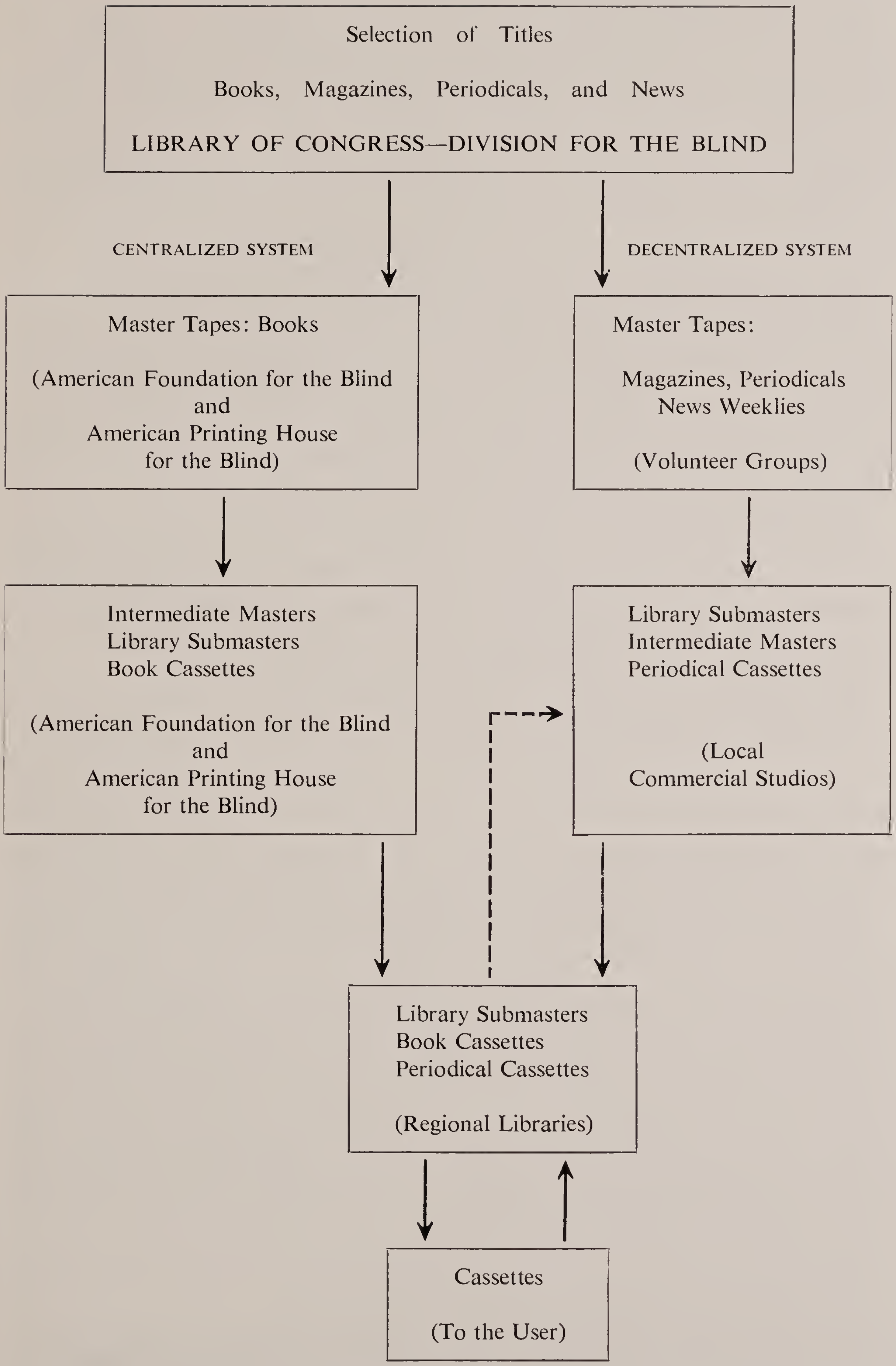

FIGURE 1 Operation of Centralized and Decentralized Facilities for Distribution of a Proposed Tape Talking Book System.

The decentralized system makes use of the professional services and equipment of a commercial duplicating audio studio as described by Sidney Himmelstein where and when they are needed (2). The advantage of this type of system is that it is ideally suited to reproduce reading material in those areas in which the present talking book program is woefully lacking. It could provide duplicate book service at the time it is requested; equate the number of copies of any title with the demand; and custom tailor the talking book service to those readers with special tastes in literature.

The system utilizing local commercial studios does not require the talking book program to acquire elaborate (and costly) recording and duplication equipment. The Library of Congress could dispense with the complications of operation, maintenance, and repair of electronic gear; nor would the Library have the responsibility for replacement of units due to the inevitable obsolescence and depreciation of equipment.

Many commercial sound studios throughout the country are equipped with high quality master recorders and high speed duplicators. Regional librarians could avail themselves of this reservoir of highly skilled technicians, simply by ordering copies of books from Library Submasters, prepared by AFB or APH and/or local volunteer groups.

The extensiveness of service and economy of operation of the proposed tape system depends upon the utilization of volunteer readers. There is an as yet untapped reservoir of voluntary readers in every state of the country. A project oriented toward recruiting and training such a national corps of volunteer readers is feasible. The resulting output of periodicals would broaden enormously the scope of the entire library service program.

The Library of Congress has now initiated one study of a decentralized type of tape duplication system. The study will attempt to evaluate the tape talking book system through a nationwide and carefully controlled but limited scale field test. A small number of commercially produced tape recorders is being distributed to members of a national test group composed of visually handicapped listeners, 500 in number. Books on tape in cartridges (e.g., cassettes) will be sent to them. The duration of the field portion of the study will be from four to six months, and it should provide data on several problem areas, including:

1. Cost of the program on a national basis
2. Cost features of all detail phases of the program
3. The number of recording and duplication facilities available commercially and uniformity of equipment used commercially

4. The establishment and standardization of duplication procedures, possibilities for quantity procurement, and geographical distribution of commercial sound studios
5. The efficiency with which the handling and mailing of cassettes is carried out
6. Listener reaction to the use and quality of tape and tape cassettes.

THE TAPE REPRODUCER

The key to the system is the tape machine. The characteristics of a tape recorder especially designed for visually handicapped persons of all ages was described by Herman Levin of Cook Research Laboratories in 1960 (4). He outlined the basic performance characteristics and operating parameters of a tape recorder/reproducer which took into consideration the limited abilities of the less skillful visually handicapped person. While the design described achieved its objective for this type of tape machine, a redesign has eliminated many of the features which were thought nonessential for the proposed tape talking book program.

The present prototype, Magna Book Mark II, was designed to achieve only the basic requirements for a tape talking book system. Among these are a cassette designed to eliminate threading of the tape; the modification of playback time for books of varied length; simple operation and control layout; and provision for further advancement in the state of the tape recording art.

This machine is designed for playback only. It incorporates tape speeds of $1\frac{7}{8}$ in./sec and $\frac{15}{16}$ in./sec, with either speed selected automatically by the cassette itself when inserted onto the machine. Rewind and Fast Forward are achieved at a speed of 30 in./sec. The bandwidth at $1\frac{7}{8}$ in./sec is 100 to 5000 cps.

The dimensions of the playback machine are 12 inches long by 10 inches wide by 8 inches high. The weight of the unit is approximately 25 pounds. The cassette weighs 2 pounds and holds 900 feet of 1 mil, one-quarter inch tape in a container $6\frac{1}{2}$ inches long by 6 inches wide by $1\frac{3}{4}$ inches thick.

The Magna Book Mark II is designed to play only the tapes stored in these cassettes. The cassette is itself a complete unit, and needs only to be placed on the machine to start. End of tape sensors are incorporated in the machine design to stop the tape before it has all run off the supply reel.

Tape motion is controlled by a mode selector. When the selector is in Stop mode, power is off and the cassette may be removed. If the power is accidently shut off the mode selector returns to Stop from any operating position.

In Fast Forward and Fast Reverse modes the tape moves at an average speed of 30 in./sec in the desired direction. In these modes as in the Play mode, power is "on" and the cassette is locked in place.

In the Play mode the pinch roller engages the capstan which meters the tape past the magnetic heads. The tape speeds of $1\frac{7}{8}$ in./sec or $\frac{15}{16}$ in./sec are selected by a speed sensor within the cassette.

A separate track selector switch enables the reader to select any of the four information channels to be played. A volume control regulates the output level from the loudspeaker or external earphones. An earphone jack has been provided for the hard of hearing or for silent listening.

The electronic circuitry consists of a transistorized preamplifier and amplifier packaged on terminal boards with printed circuits. A circuit breaker replaces the customary fuse.

The exterior of the machine is streamlined in shape, with two sloping sides for guiding the cassette into place. The stacked five-inch tape reels are driven by a coaxial drive coupler whose teeth mesh with matched gears in the cassette and in the tape machine.

At a speed of $1\frac{7}{8}$ in./sec the cassette offers a record duration of $6\frac{1}{2}$ hours, playing the four tracks in sequence on 900 feet of 1 mil plastic tape; double this time is available when the speed is changed to $\frac{15}{16}$ in./sec. It is anticipated that still longer durations can be achieved with $\frac{1}{2}$ mil tape, to a maximum of 25 hours.

A special feature of the tape reel is that it may be adapted to commercial duplicator slaves for direct copying. With bulk erasure the book tape may be reused and thus effect greater economy. Shelf storage of obsolete or excessive copies of books can be minimized in this manner. All functions of the playback machine are brought into use by switching the controls designed for simplicity of operation and for elimination of the need for rehandling of the cassette during play.

CONCLUSIONS

In summary, the proposed Library of Congress tape talking book system comprises playback machines and cassettes designed for the visually handicapped used within a production and distribution structure specifically adapted to this talking book format. The potential book time capacity of the cassette is commensurate with the varied requirements of the talking book program.

The original recording and duplication of book tapes would be performed within the frame work of existing commercial production recording studios utilizing high speed duplicating transports and electronics. Full expansion of the talking book tape program thus can be realized by dovetailing the operation of the present centralized system with a decentralized system using commercial audio studios distributed geographically throughout the United States.

I would like to express thanks and appreciation to the technical staff of Cook Engineering Company who contributed their ideas and their technical skills to advance the project to its present status.

APPENDIX: DESIGN GOALS OF THE MAGNA BOOK TAPE PLAYBACK MACHINE

A. BASIC DESIGN

Transport Mechanism

1. The transport mechanism must be rugged, of lightweight construction, and designed for a minimum of maintenance.
2. All subassemblies must be easily replaced and/or adjustable by unskilled personnel.
3. The design must be adaptable to production in quantities of 10,000 units or more at reasonably low costs.
4. Controls must be simple and fool proof, yet reliable in operation.

Cassette

5. The tape is to be contained in a cassette which can be handled easily by a visually handicapped person.
6. The cassette must be capable of storage on a library shelf and of sufficiently rugged construction to withstand repeated shipment through the mails.
7. The reels must be compatible with available commercial duplicating equipment and of standard design characteristics.

Electronic Assembly

8. The electronics shall be designed for simplicity, and must meet the required performance standards (see below).
9. Printed circuit terminal mounting is suggested as providing the greatest component packing density and simplest repair techniques.

Performance Requirements

10. Electrical requirements
    a. Frequency response (at $1\frac{7}{8}$ in./sec). *Design goal*: 80-7600 cps. *Acceptable*: 150-5300 cps.
    b. Signal/Noise Ratio. *Design goal*: 45 db. *Acceptable*: 35 db.

c. Distortion. *Design goal*: 0.80% @ 2 w output. *Acceptable*: 1.5% @ 2 w output.
d. Wow and Flutter. *Design goal*: 0.30%. *Acceptable*: 1.40%.
e. Power output. *Design goal*: 2 w. *Acceptable*: 1 w.
f. Line tolerance. *Design goal*: 105-125 v @ 60 cps. *Acceptable*: 110-120 v @ 60 cps.

B. DESIGN PARAMETERS

1. Cassette, loaded
   The cassette, loaded, consists of two stacked and coaxial mounted 5-inch metallic reels in a case whose dimensions are $6\frac{1}{2}$ inches by 6 inches by $1\frac{3}{4}$ inches.
2. Use of standard tape
   Tape is of one-quarter inch width; 900 feet in length; on 1 mil Mylar base.
3. Four track recording
   Four separate tracks of standard width and spacing (0.040 inch track and .0280 inch spacing).
4. High resolution magnetic heads
   Two head assemblies are to be used, each accommodating two tracks. They are to be mounted so that playback is possible with tape running in either the left-to-right or right-to-left direction. Each of the four individual heads can be separately switched. The head gaps are 40 micro-inches (thus allowing good high frequency resolution).
5. Single capstan
   Only one capstan is required even though tape may be played in both directions.
6. Headphone outlet
   A jack type outlet is to be incoporated which will cut off speaker output when the headphone jack plug is inserted.
7. DC power supply
   The dc power supply for transport controls and the electronic circuitry is to be delivered from a transformer type full wave power supply.
8. Electronic circuitry
   a. The preamplifier will consist of a two stage, RC coupled, and transistorized amplifier.
   b. The power amplifier will consist of a driver stage coupled to one pair of push-pull transistors to drive the loudspeaker output. (A push-pull transistorized output circuit was chosen because of its high power and low distortion.)
9. Automatic stops
   Located on the outside of the magnetic heads will be a pair of contacts which touch the back side of the tape at all times. The contacts will sense the end of the tape in either direction when the gap between them is bridged by a piece of conductive cuing tape affixed to and just before the ends of the tape. (The function of the cuing tape is to complete a

circuit causing a control relay to be de-energized, thus placing the machine in the Stop mode.)

10. Magnetic playback head
    DC Resistance: 150 ohms
    Gap: 40 microinches
    Track Width: 42 mils
    Track Spacing: 0.136 inch
    Inductance: 0.5 henry
    Impedance: 3000 ohms @ 1 kc/sec
11. Impedance
    Loudspeaker output: 3 ohms
    Earphone output: 10 ohms.

REFERENCES

1. *Application Study, Magnetic Tape Reproducers/Recorders for Talking Books.* Morton Grove, Illinois: Cook Research Laboratories, 1959. Report F-PR 172-1 (Contract B59-DC-6).
2. Himmelstein, Sidney, "Tape Duplicating Systems for Talking Book Program," *J. Audio Eng. Soc.,* Vol. 9, No. 2 (April 1961), pp. 102-106.
3. Korb, Alfred, "Tape Talking Book System for the Blind." Paper read at the October 1960 Annual Meeting of the Audio Engineering Society, New York. Preprint No. 161.
4. Levin, Herman, "Tape Recorder Designed for the Blind." Paper read at the October 1960 Annual Meeting of the Audio Engineering Society, New York. Preprint No. 162.

THE TAPE TALKING BOOK IN SCANDINAVIA

HANS CHRISTIAN JORGENSEN
Danmarks Radio, Copenhagen, Denmark

INTRODUCTION

The question of starting a talking book service on tape for the blind in the Scandinavian countries was first discussed at a meeting in Oslo in the Autumn of 1954 by representatives of the Scandinavian associations for the blind who attended. The appearance of rather low-priced tape recorders on the market had made it possible to provide the blind with such an apparatus and, in a simple way, to make necessary copies for building up a talking book library. The Tandberg recorder of Norwegian manufacture proved to be very easy to handle, and the several associations for the blind agreed to recommend this recorder and try to procure means for the purchase of a number of tape machines to be distributed among the blind.

At that time other recorders had a slowest speed of $3\frac{3}{4}$ in./sec, while the Norwegian recorder had also arranged for a speed of $1\frac{7}{8}$ in./sec, and the quality of voice reproduction at that speed was quite good. The possibility was also discussed of having a tape cassette apparatus constructed. As the Royal National Institute for the Blind/St. Dunstan's, in England, had worked on this matter for several years without having come at that time to a final design, the matter was given up.

In 1956, a year and one-half later, a conference on the talking book for the blind was arranged in Paris under the auspices of the American Foundation for Overseas Blind (AFOB). In many European countries a talking book service had already been started on discs, and on tapes on a more or less limited scale. Nearly all the participants at the conference agreed that a talking book service could be done best with tapes. They also agreed that tape as a medium would be much cheaper than discs since most of the countries needed only a few copies of each book title. The problem was, therefore, to find an apparatus suitable for the blind: so far no flawless cassette system had been developed. It was also pointed out that the apparatus in question should be arranged for both recording and reproduction because many blind persons wanted to use their machines as an aid in communication with other blind individuals.

The tape speed was discussed also at the Paris conference. The participants from Germany and some other countries did not consider it possible to obtain a sufficiently high quality of reproduction when using a speed of $1\frac{7}{8}$ in./sec, but the Scandinavian participants emphasized that from their experience a pretty fair quality could be attained, and furthermore that in the near future most tape machines would include this low speed in their design. This was an economic problem of great importance, if the number of tapes were doubled for each book due to the requirement of a higher tape speed.

At the conference the AFOB announced that a duplicating center would soon be started at Paris, and that all the European countries could make use of it. It was a little difficult for the participants at the conference to make up their minds about the proposal from AFOB. Roughly speaking, the countries might be divided into two groups on this question. One group comprised those countries which themselves had the possibility of starting a copying center. The other group included all those who did not see this possibility. To the first group belonged the northern and central countries of Europe, and to the second group most of the southern countries.

From 1955 and onwards, work with the talking book went on steadily increasing in the Scandinavian countries. Small libraries of talking books were built up, and recorders were bought and distributed among the blind. The financing of the recorders was made available partly by the associations for the blind, and partly by the blind themselves. In Denmark the purchase of most recorders was financed by the State.

The first tape talking books were rather imperfect from a technical point of view, and not many blind persons had recorders. Nevertheless, interest was great. A latent need for talking books had been stirred and the question became how to try and meet this demand.

Not many books were made in these years and Sweden, which was the first Scandinavian country to start the tape talking book program, had up until 1957/1958 a library consisting of only about 150 titles.

In the beginning copies were made simply by parallel coupling of recorders, and double normal speed was used for making copies. The recording of masters was at first made by a common home type of recorder. Later on a semiprofessional recorder was procured in Denmark, and to secure better quality the masters were recorded at a speed of $3\frac{3}{4}$ in./sec.

PRESENT PRACTICE

Now, only professional recorders are used in Denmark for making the master tapes, and recording speeds are 3¾ in./sec and 7½ in./sec. The lower speed is that normally used, while the higher speed can be used in those rare cases in which music is to be recorded. Technical specifications for the recorder at a speed of 3¾ in./sec require a frequency range from 100 to 8000 cps ± 2 db; a signal/noise ratio of at least 50 db; distortion not exceeding 3.0 percent for full modulation; and wow (measured peak to peak) not exceeding ± 0.3 percent. The apparatus is furnished with controls for immediate start and stop so reading errors can be corrected during the recording. The quality of reproduction can be checked continuously because the recorder has a separate playback head as well as a special monitor amplifier which is switched to the loudspeaker during the recording.

MAKING THE TAPE MASTERS

The use of a studio for the recording results in better sound quality than using an ordinary room, and one is much more independent of disturbing noises to which many readers are very sensitive. The studio must be constructed along the same lines as the usual broadcasting studio for best results, even if it can be smaller. It must be equally well damped on the walls, with a reverberation time of about 0.3 to 0.4 second and with a smooth attenuation of the lower frequencies. Of course, there must be the necessary auxiliary signal installations between the studio and the recording place so that contact between the two rooms is always maintained.

While voluntary readers are employed in Norway, only professionals who are paid for their jobs read on talking books in Sweden and Denmark. Various kinds of readers are employed: students, state radio announcers, actors, actresses, and so on. It's a really hard job to read for several hours without becoming tired, and the readers must have the ability, in addition, to read in such a way that they give the listener a fair idea of what happens in the book.

All sorts of talking books are made; about 70 percent are of light literature. Much weight must of course be attached to whether or not the book is suited to reading aloud. Sometimes books that would be regarded too difficult to read to oneself are better suited for listening, and have found a widespread public; one example is the book *La Chute* (*The Fall*) by the French author, Camus. In Sweden one reader has made a specialty of giving an account of current movies; it is done so skilfully that the listener has a really vivid impression of the films. Comparatively few talking books for children have been made, as it has been regarded more important that blind children learn braille, and are skilled enough to read braille books.

In Norway the librarian chooses the books to be read. In Sweden and Denmark there is a committee of representatives from the associations for the blind. To choose a book to read aloud requires a profound knowledge of the book, and it may sometimes be necessary to edit the book before it can be used as a talking book.

The talking book libraries built up in Sweden and Norway belong to the associations for the blind but are supported by the State; the essentially similar Danish library is entirely State owned.

Of course the size of the Scandinavian talking book libraries is very modest in comparison with other libraries. In Sweden there are now about 1100 titles in the talking book library; in Norway and in Denmark about 800. There are four to seven copies of each book but the average number of copies per book has been increasing in recent years. This is quite comprehensible when we learn that in Sweden 34,000 talking books were borrowed; in Norway 26,000; and in Denmark 52,000 during 1961. The number of titles increases by 250 to 300 per year.

RECENT TECHNICAL INNOVATIONS

While the copying of the talking books was previously done by means of ordinary home recorders, more professional equipment was introduced in the years 1958/1959. In Sweden, the association for the blind bought American Ampex equipment with one master machine and six slave machines at a price of about $20,000. In Norway similar equipment was acquired by a corporation called Soundtape Service. This company was formed by the association for the blind, together with the Welfare Office of the State for the Merchantile Marine. The Ampex equipment, the same as used by AFOB in Paris, was arranged for making copies for the playing speed of $1\frac{7}{8}$ in./sec, using a copying speed of not less than 60 in./sec. An ordinary two track 7-inch tape reel with about four hours playing time can be copied in less than four minutes.

In Denmark copying equipment which was made by the Danish firm, Lyrec, is used; and it was procured partly by means that had been placed at the library's disposal from the Danish Association for the Blind. The copying equipment includes two master machines, a control panel, and ten slaves.

The equipment copies with eight times increase in speed—and a playback speed of 30 in./sec for the master machine and a recording speed of 15 in./sec for the slaves. As the speed of the master tape and the copies are different, and the contents of the two tapes must be the same, a 7-inch reel with 1 mil tape is used for the master, and 5-inch reels for the copies. The reason for the use of 5-inch reels for the copies is that when the talking book was introduced in Denmark many blind persons had already acquired recorders for which the biggest reel size was 5 inches. Later these 5-inch reels, with a playing time of three hours, were found very convenient in use for the talking book.

The slave machines, which have only light holdback tension to ensure that the 5-inch reels are not too tightly spooled, are provided with an erasing head, two recording heads, and a double track playback head. This latter can be switched to a control amplifier with a loud-speaker and a volume indicator to monitor what is being recorded.

Figure 1 shows the master machine to the left, and to the right the panels with slave machines and recording amplifiers. The volume indicator in the

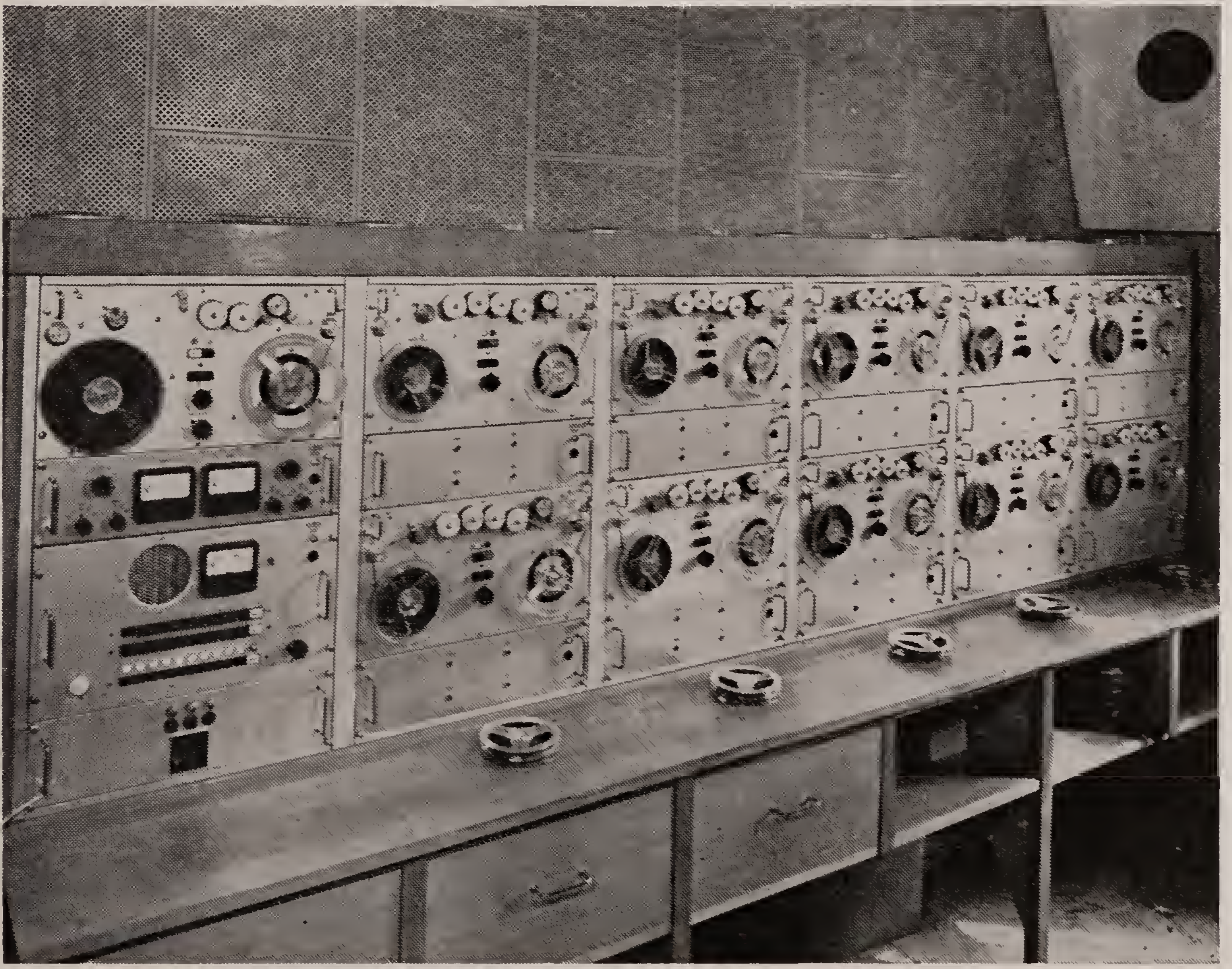

FIGURE 1 Copying Equipment Used by the Talking Book Library, Denmark. (Equipment by Lyrec, Copenhagen)

control panel which checks the volume can be used in addition to check the alignment of the heads in the master and the slave machines.

As it is usually speech which is to be recorded it is possible even with as low a speed as $1\frac{7}{8}$ in./sec to secure a good quality tape. The signal/noise ratio is about 45 db, and the frequency response characteristic for copies is from 100 to 4500 cps ± 2 db.

Contrary to the case in Sweden and Norway, the master tapes in Denmark are recorded with a speed of $3\frac{3}{4}$ in./sec to secure a quality that is always superior to that of the copies.

DISTRIBUTION OF TALKING BOOKS

All blind and visually impaired persons in Scandinavia have the right to borrow tape talking books. It may be a little difficult to judge whether a person is visually impaired or not; and there arise cases of illness which hinder a person from reading but not from seeing. A medical certificate for visual impairment from a doctor is sufficient for eligibility if the person concerned is not a member of the association for the blind. Access to borrow can be obtained by applying to the library of talking books, or to the local consultant for the blind, and if the application is approved the borrower will receive an access card and the regulations concerning loans. The borrower has the right to borrow one book of three tapes each time, and more lengthy books have to be divided into segments. A book of three tapes gives a listening time of 9 to 12 hours. When more books have been produced it will of course be possible to borrow more tapes each time.

The borrowing time is three weeks in Sweden and Norway, and one month in Denmark, but shorter times may be fixed for books for which the demand is great. The books can be borrowed by personal application or through a phone or letter order and in Sweden and Norway where the distance to most of the borrowers is great, nearly all loans are forwarded by mail. The forwarding and remittance of talking books are by international agreement free of postage when the parcels are marked "Writings for the blind."

Talking books are sent in special fiber containers which are very resistant to damage and they must be returned by the borrower to the library in the same containers. While you can quickly check whether an ordinary book is damaged, it takes more time to check a talking book, and it has proved to be necessary to inspect every tape. At the beginning of this tape service one had to reckon with more or less damage to 10 percent of the tapes, but this factor dropped very soon to 5 percent and it has steadily gone down.

It may now be estimated to be 2 to 3 percent. It is of course necessary to use a Mylar base tape of good strength.

On the container, and within a folder an address card is placed which on the back carries the address of the library, and has only to be turned over when the container is sent back to the library. The title of the book is both typewritten and brailled on the container as well.

Most of the recorders which the blind possess have been distributed through the associations for the blind, and grants have been made to those who wanted a recorder. This support has often amounted to the full cost of the recorder, the money being paid by the associations for the blind in Sweden and Norway, and in Denmark by the State.

Even if an instruction manual is supplied with the tape recorder it was expected from the outset that the blind would have difficulty in handling the apparatus and in changing the tapes. Time has shown that it went far better than expected. Of course there are still a number of old people who need help with their tape recorders, but as time goes by the younger and middle-aged generation will find it just as easy to use a recorder as a telephone. If we switch to a cassette type apparatus some time in the future, the machines will have to be arranged for recording also, since many blind persons now use the tape recorder as an instrument not only for sending communications to their friends but as an aid to their memory also.

Recording machines for the blind may become inferior as they age in use, and in spite of the very little trouble with quality, in spite of the low speed of $1\frac{7}{8}$ in./sec for the copies, it has been found wise to have the recorders checked regularly. In Denmark it is therefore intended to supply the consultants for the blind with aligning tapes containing so-called white noise so that they can check the quality of the recorders simply during their visits to the blind user.

DATA ON THE TALKING BOOK USERS

It is generally estimated that 0.15 percent of the population in Western Europe is blind, but this percentage seems to be a little too high for the Scandinavian countries where the war blinded and congenitally blind during recent years have been reduced considerably. A better figure might be 0.12 percent of the population. This gives 9000 for Sweden; 5400 for Denmark; and for Norway, 4300 blind and visually impaired persons. The association for the blind in Denmark has tried to trace all blind and visually impaired people, and has contacted about 5100 persons, of which the majority are old people.

The activity of the talking book centers in Scandinavia can be seen from the figures in Table 1.

The growth of the talking book libraries in Scandinavia may perhaps be judged best from the Swedish figures with less than 100 borrowers in 1956 and 3100 in 1961.

It is not the case that all blind persons should listen to a talking book instead of learning to read braille. All young blind people should learn braille and use the braille library which, of course, in no way must be less well provided with books than the talking book library. We must face the fact however, that the number of old people among the blind will steadily increase, and the percentage of the blind who really can read braille has fallen in recent years; it may now be judged to be 20 to 25 percent.

We cannot expect that all the blind and the visually impaired will profit from talking book libraries; the maximum percentage of borrowers to the number of blind will be far lower than 100 percent. In Denmark, where the figure is now about 46 percent it is estimated that it will be difficult to exceed 75 percent. But it is to be hoped that within a very few years the goal will be reached wherein every blind person who wants can borrow talking books, and acquire a tape recorder either paid for in part by himself or given to him free of charge.

With the increasing number of borrowers the demand for more books will grow, and one way to fulfil the demand is to produce more copies. While in the past there were perhaps 3 to 4 copies of a title, the average number of copies is now 5 to 6 and in the next few years it will undoubtedly be increased to 7 to 8.

On the whole, the talking book library offers a great advantage over a general library, in that an unlimited number of copies can be provided in a very short time. You can, for instance, make 25 copies of a book for which there is a great demand now and a few months later erase the copies and use the tape for another book.

TABLE 1

ACTIVITY OF TALKING BOOK CENTERS IN SCANDINAVIA

	Population (millions)	*Total No. of Blind Persons*	*Number of Borrowers*	*Percentage of the Blind Population*	*Book Titles*	*Copies*	*Borrowed Books in '61*
Sweden	7.5	9000	3100	34	1100	6700	34,000
Denmark	4.5	5400	2500	46	800	4200	52,000
Norway	3.6	4300	1400	33	800	3500	26,000

One important question is how much it costs to make a talking book. A talking book consisting of three tapes with a total playing time of 10 to 12 hours costs about $100 to produce, including fees to readers and technicians, copyright tax to the author, and price for cassettes (but exclusive of overhead and costs for equipment). Copies will cost about $10 to $12 each.

In each of the Scandinavian countries about ten persons are employed in the talking book service at the library for the blind. The annual expense for the talking book program in Sweden and in Denmark is about $60,000, and in Norway about $30,000. In Denmark, the talking book is paid for by the State; in Sweden and in Norway, by the associations for the blind, but two-thirds of the cost is refunded by the State. In Sweden and in Denmark a royalty is paid to the authors for the recording of their books, but in Norway nothing has been paid to them so far. This question has yet to be settled with the Norwegian authors.

The talking book centers offer more services than the production and distribution of talking books. They copy various papers for the blind, including a music paper, an Esperanto paper, a paper for physiotherapists, etc., and in Denmark a special service for a talking newspaper has been established.

This newspaper is published twice a week and the blind pay about 75 cents monthly for it. It contains news and topics from daily papers and periodicals, preferably such things that have not been broadcast by the radio press news. A copying equipment similar to that previously mentioned has been procured for the publication of this talking newspaper. It consists of a master machine and ten slaves, and has the advantage that all the slaves are furnished with erasing heads; this is necessary because the tapes are returned from the subscribers. At the moment, there are about 400 subscribers, and the number is still increasing.

The importance of the talking book cannot be overestimated. It has given the blind a richer life, and has contributed to the diminishing of the chasm between the seeing and the blind. The motto for the talking book could be expressed in the motto of the Swedish association for the blind: "A light in the darkness of the blind."

THE TAPE TALKING BOOK IN CONTINENTAL EUROPE

MAURICE R. BERNARD
American Foundation for Overseas Blind, Paris, France

In April 1956, on the invitation extended by the American Foundation for Overseas Blind (AFOB), a conference was held at its Paris headquarters to consider coordination and development of talking book services in the European and Middle Eastern region of that agency's services. The conference was attended by representatives of fifteen countries who exchanged suggestions to promote talking book service in open discussion.

One result of the conference was the establishment by AFOB in Paris of a duplicating service of the best quality possible. Ampex Model 3200 tape duplicating equipment was placed on order for the installation, consisting of one master reproducing machine and associated amplifiers; six slave machines with two speed tape drive; and two copying rates available; 30 in./sec and 60 in./sec.

Under the plan of its organization, the Paris center was to receive master tape recording from all European and Middle Eastern countries who wished to use the service, and was to make as many copies as requested. It was also decided that AFOB was prepared to bear 50 percent of the total cost of duplicating tapes in Paris, the other 50 percent being paid by the contributing countries.

The first tape copies to be made under the new plan were prepared for the Finnish agency on 21 November 1956.

Since that time, the AFOB Paris duplicating service has not ceased to grow in a steady and gradual manner, as the data in Table 1 will show.

Ninety-five percent of the yearly total of feet copied is recorded on polyvinyl chloride base 1 mil thick, and is similar to the tape made in Germany.

What follows in this report is a review of all the European talking book services which participated in the development of this service.

Among the European countries having a talking book service on tape for the blind Germany takes without doubt the prominent place. It can

TABLE 1

GROWTH OF DUPLICATING SERVICES, 1957–1962, AT AFOB PARIS TAPE CENTER

Year	*Number of Feet Copied (in millions)*
1957	6.6
1958	10.5
1959	11.6
1960	12.5
1961	14.0
1962 (Jan.–Apr. only)	5.0

be estimated that in the period 1957 to 1959 approximately one-third of all the tape copies produced were made for Germany. The main libraries for the blind in West Germany are located in Berlin, Essen, Hamburg, Marburg, Munich, Münster, Saarbrücken, and Stuttgart—but the most important are probably those of Marburg and Münster.

The Marburg library is directed by Professor Dr. Carl Strehl. This library has a copying service of its own, consisting of ten domestic slave recorders (made by Vollmer) that can be fed either by the same reproducing master, or can be split into two sections of five slaves each; in the latter case, each set of five slave machines is provided with one master machine. Copies are made at a ratio of four to one, with upper and lower tracks being made simultaneously; the original recordings are made at 3¾ in./sec (9.5 cm/sec).

Until October of 1961 Münster had a duplicating equipment setup similar to that installed in Marburg, but consisting of ten Telefunken commercial type recorders copying only one track at a time; this equipment did have provision for both 3¾ in./sec (9.5 cm/sec) and 7½ in./sec (19 cm/sec) tape speeds. The growing importance of the library during the last few years, however, under the direction of its Director, Dr. Thickötter, has been responsible for a change to more versatile equipment; the new Vollmer Geräte Fabrik (Plochingen/Neckar) was installed in October, 1961. This equipment was designed to special order, and consists of one reproducer master and ten slave copying machines, each about the size of a commercial tape machine; two copying speeds are available (30 in./sec and 15 in./sec, or 38 cm/sec and 76 cm/sec), and both tracks are recorded simultaneously. The master machine can use reels up to ten inches

(250 mm) in diameter, while the slave machines can use reels of a maximum diameter of seven inches (175 mm). The complete configuration cost is in the order of $5000.

One powerful impetus for the purchase of this equipment was the publication of four periodicals every month in talking book form; they are:

1. *Die Zeit* (The Times)
2. *Westerman's Monatschrifte* (Westerman's Monthly)
3. *Tönende Rundschau* (The Outlook in Sound)
4. *Der Horizont* (Horizon)

Die Zeit is a weekly review of political events around the world. Duplication is made in 250 copies monthly. *Westerman's Monatschrifte* is a monthly magazine of general interest and includes short stories, adventure yarns, and other fiction. This magazine has had an early acclaim, and duplication amounts to some 400 copies monthly. This figure will soon increase to 500 or 600 copies since subscriptions are now being taken not only in Westphalia but in many other parts of West Germany as well. The expenses have increased to such an extent that the Münster library has been forced to make a yearly subscription charge of ten marks ($2.50). The *Tönende Rundschau* is also a monthly, a review of legislative activity, and with articles from commerce, medicine, and so on. Duplication needs are of the order of 100 copies. *Der Horizont* is another monthly, devoted to articles concerned with Christian Science; 25 copies are distributed.

There are, in all, about a thousand titles available in the Münster library, but Dr. Thickötter's aim is to bring this total to 3000 as soon as possible.

The exchange of books between libraries within West Germany and with other German-speaking countries is well organized. Each library is advised regularly of books which have just been recorded so that they can send for their own copies in due course.

The Netherlands has a talking book program second only to West Germany in the extent of its activities. The libraries in both Amsterdam and in Rotterdam own well designed studios for speech recording, and the quality of the recordings is very good. Although it may be difficult to give an exact figure for the number of titles available, one can infer from the orders for copies which the Paris center has processed, that it would be fairly high, perhaps between 300 and 400.

Grave, in the east in the Netherlands, has a recording studio and a small duplicating setup also. Though definite information on the importance of their library is not at hand, we can infer from the amount of copying the Paris center has done for them that the number of titles available must be fairly large; approximately two million feet yearly are copied every year since 1958.

Yugoslavia also has a talking book program. The recordings sent to the Paris center are of good quality. Some copying work was done in Paris for Belgrade in 1958; since that time, the yearly total of feet copied has risen steadily. In 1961 nearly two million feet of tape was used for their copying.

In Switzerland, Dr. and Mrs. Belbling, in Zürich, have pioneered the talking book. About two years ago, the library had grown so large that it had to be reorganized and the staff increased in number. The growth in copying work done at the Paris center from this source is shown in Table 2.

TABLE 2

GROWTH IN TAPE COPYING FROM ZÜRICH, SWITZERLAND

Year	*Feet Copied* (*thousands of feet*)
1957	35
1958	390
1959	800
1960	800
1961	850

Most of the recordings are made by volunteers in their homes, at a speed of 3¾ in./sec (4.75 cm/sec), and copies made at 1⅞ in./sec (2.3 cm/sec).

Colonel Cobolli directs the talking books service in Italy. The tape equipment used for the master recordings, editing, and copying are all standard commercial Grundig devices; it consists of three Model TK-8 machines with speeds of 7½ in./sec (9.5 cm/sec), 3¾ in./sec (4.75 cm/sec), and one Model TK-16, with speeds of 3¾ in./sec (4.75 cm/sec) and 1⅞ in./sec (2.3 cm/sec). Most of the recordings are made at a tape speed of 7½ in./sec using only one track of the two track machine. The editing and copying are then made at a tape speed of 3¾ in./sec. A few copies are also made by duplicating from the 7½ in./sec masters to 1⅞ in./sec tape for the benefit of those readers having the smallest Italian-made Geloso recorders, which can use reels with a maximum diameter of four inches. The readers are professional actors from the Italian radio who accept modest remuneration (about one dollar per page). There are

35,000 blind persons, including both the war blinded and the civilian blind; of these, only 250 or so own tape machines. One hundred twenty of these machines, the major proportion of them commercial Grundig types, were given to the users by the association for the blind. The Italian Unione has also been negotiating for some time with the Valmartina Company (Florence) for a course in English language teaching which was edited in part by the British Broadcasting Corporation.

Two organizations in Belgium are engaged in talking book services. One is La Ligue Braille, which has its own recording studio and edits a small number of titles regularly each month. Copies made by the Paris center amount to five to six hundred thousand feet yearly. The other organization is the Ouevre des Aveugles de Guerre (Association for the War Blinded) which, though operating with a very small budget, provides what services it can; it is directed by Major Delvaux.

Data is very sparse regarding talking book services in Austria. We do know that the Union for the War Blind, under its Chairman Hirsch, owns an Ampex Model 3200 duplicating system with one master reproducer and two slave units, installed in September 1959. They also have a studio for talking book recording equipped with German Telefunken microphones and two Telefunken Type M-5 tape recorders.

In France, the Union des Aveugles de Guerre (Association of the War Blinded) supplies by far the largest proportion of talking books recorded. Having obtained permission from the Radiodiffusion Française (French Radio Network) to copy a number of books read by professional actors, M. Gaston Louis Roux, its Director, has initiated a program in which the Union edits the tapes produced, and makes both disc and tape talking books from them. La Cause (The Cause), another but much younger organization located at Poissy, near Paris, began in 1959 to record a number of titles on tape; the studios of the Union are used for this purpose. During the years 1960 and 1961, the small but energetic organization recorded 80 titles for their library on tape. Table 3 will indicate the growing importance of the talking book service rendered by this group.

La Cause is planning further expansion of its facilities and, according to its Director, Mlle. Durrleman, one of the first improvements is the acquisition of their own recording studio. The group is well aware that one of the major obstacles to their growth in service is the difficulty (which is not confined to France) of supplying talking book readers with tape machines at as low a cost as possible. One solution currently used is to rent the machine to the reader for a fee of NF 5.5 for a six month period (about one

TABLE 3

TALKING BOOK PARCELS SENT TO SUBSCRIBERS BY LA CAUSE

Year	*No. of Parcels*
1959	56
1960	365
1961	699
1962 (First Quarter only)	240

dollar per month). When the rental period has ended, La Cause does its best to help the subscriber keep his machine if he wishes to do so: he can pay for the machine in monthly installments which can be spread out over a period of two years. The machine currently supplied is made by Phillips (Netherlands) since La Cause can acquire them at a substantial discount from the manufacturer. In the last two years under this program, the organization has purchased 32 machines, and it plans to acquire several more in the near future. About 90 titles are on file in the library of La Cause at present, each title having four copies.

TECHNICAL CONSIDERATIONS

I should like to conclude this summary of talking book activity on tape in Continental Europe with a few technical remarks concerning standards and procedure.

By 1956, a number of libraries (and especially the German and the Belgian) were recording tape masters at a speed of 7½ in./sec (19 cm/sec) and ordering copies at 3¾ in./sec (9.5 cm/sec). The reason given for this practice was that a better copy could be made from the tape recorded at the higher speed. My personal feeling was then, and is now, that a much better copy at 3¾ in./sec can be obtained from a good master recorded at the same speed than from a copy made at a higher speed. This is so for one obvious reason, namely that if one cannot reproduce well the frequency range from 8 to 12 kc/sec, at 3¾ in./sec, then what is the use of having them recorded on the master at 7½ in./sec?

In 1956, at the inception of the Duplicating Center at AFOB (Paris), most libraries were recording master tapes at 7½ in./sec and asking for copies at 3¾ in./sec. At that time we tried to educate the libraries to the uselessness of this procedure, and I must say that by this time, fully 85 percent of the European countries (Scandinavia excepted) have changed over to masters recorded at the slower speed; the countries now include the Netherlands, West Germany, Yugoslavia, Israel, Italy, France, and Belgium. The only current exceptions are the Ligue Braille in Belgium (master tapes recorded at 7½ in./sec, copies ordered at 3¾ in./sec) and Switzerland (Zürich, master tapes recorded at 3¾ in./sec, copies ordered at 1⅞ in./sec).

Basing my opinion on some studies made in the United States, I should say that at the present state of the art of sound recording and reproduction, the best speed we can recommend for talking book services is 3¾ in./sec for both master tape and copies. A comprehensive analysis of speech has been made in this country by I. B. Crandall (1). His records gave the predominant frequency components of speech, and the relative amount of energy at each frequency within the speech band. The results confirm the previous work of Miller and Paget, and show that in the male voice, the maximum energy content is found at 120 cps; the female voice displays an energy peak approximately one octave higher (4, 5). In addition, measurements made by Fletcher on the interpretation of speech through tests of articulation indicate that it is the high frequency sounds which are most essential to intelligibility, in spite of their low energy content (2). Deducing from this data, it can be shown that clarity of speech is unimpaired if all frequencies up to 500 cps are blocked out (filtered) entirely, in spite of the fact that 60 percent of the energy content is thereby removed. It is important to observe, however, that the ear has its maximum sensitivity in the region of 1000 to 4000 cps.

It appears, from the analysis of the speech records of several speakers by Fletcher, that although different acoustic spectra are obtained for each speaker the regions of maximum amplitude are nevertheless always located in approximately the same place in the speech band. The spectrum of the vowel "e" is, for example, characterized by a broad peak in the region of 300 and 2300 cps; for the vowel "a" the peak is seen in the band of 500 to 1900 cps. These records also show that there are high frequency sounds of high amplitude, the mean frequency peak being located at approximately 3200 cps.

Finally, research conducted by LeBel and Temple indicates that for maximum speech intelligibility, the criteria for good sound systems should include a specification of a frequency response within 2 db from 120 to 4000 cps, with a maximum of 5 db variation at 50 and 6000 cps (3).

We believe, therefore, that for the talking book, any recommendation for magnetic tape recording and reproduction should take into consideration the terms of Publication 94 of the International Electrotechnical Commission, since these fulfill the requirements by permitting a 2 db variation from 100 to 3000 cps, increasing to 5 db at 50 and 6000 cps, at a tape speed of 3¾ in./sec.

May I conclude with a wish? We are today confronted by several alternate standards for recording and reproduction characteristics on tape (among them: NARTB, AME, CCIR) and, although the situation is not quite as bad as ten years ago in the controversy over the standard disc characteristic the situation is unsatisfactory—and certainly a hindrance to tape exchange among the various countries engaged in talking book services.

I believe that it would be to the benefit of all concerned if a truly international standard could be defined for the different tape speeds now in use for both professional and nonprofessional use. The CCIR standard, which is supposedly such an international standard, is in fact a European standard only. There is surely a need for such a standard which would help promote tape exchange on a broader scale than ever before. This is surely a matter which may be taken up by the Magnetic Recording Industry Association of the United States and the European Commission in Geneva at their next meeting.

REFERENCES

1. Crandall, I. B., "Sounds of Speech," *Bell System Tech. J.*, Vol. 4 (Oct. 1925), pp. 586-626.
2. Fletcher, H. *Speech and Hearing in Communication.* New York: D. Van Nostrand, 1953.
3. LeBel, C. J., and Temple, "Standard for Educational Recording Machines," *Quar. J. Speech,* Vol. 35, No. 4 (1950).
4. Miller, D. C. *The Science of Musical Sounds.* New York: Macmillan, 1916, p. 215 ff.
5. Paget, R., See *Proceedings of the Royal Society,* esp. No. 102 (1923), p. 752; No. 106 (1924), p. 150; No. 114 (1927), p. 98.

PROBLEMS OF TAPE DUPLICATION

HELLMUTH ETZOLD
Consulting Physicist, New York, New York

I shall start this very brief presentation of the physics and the technology of tape duplication with an apology. I am sorry that I cannot proffer to you a radical new development which came to light only yesterday and which solved all the problems which we were not able to solve before. I can offer you only a short review of some of the principles of tape recording and duplicating, and point out some of the considerations that need special attention in methods of duplicating.

Although I cannot offer any radical departures, I can perhaps offer a scheme with which you can anticipate these before they arise in the future. If you will refer to Table 1 you will see the possibilities laid out before you. This is essentially the same table which I used to present to my students at Berlin University many years ago. In it you will find a review of all possible recording methods; some indication of whether or not they are currently used; what form some of the current applications take; and what possibilities remain for exploitation in the future. The table has remained in its original form for quite a few years, and there is actually only one development of a radical nature which has appeared in the recent past, which I shall add in my comments below.

To the left of the table I have listed all the available methods which can be used to register sound in recording. At the top of the table I have listed most of the physical forms of the vehicle in which the recording is made. The boxes fill in the information corresponding to the cross-indexing of these two terms, and show past and present applications.

At the basis of all recording methods lies the elementary principle of recording: a relative motion between a recording device and a vehicle. In recording any periodic function, in fact, we can represent the information recorded by the function $\lambda = v/f$ in which the wavelength recorded (λ) is equal to the velocity (v) of the carrier over the frequency (f) of the signal.

As reference to Table 1 will indicate, there are already a good many areas in which an application has already been made of the possible

TABLE 1

PRINCIPLES OF RECORDING VERSUS PHYSICAL FORMS OF VEHICLE

Principle of Recording	*Physical Form of Vehicle* *Disc*	*Drum*	*Sheets or Belts*	*Tape*	*Wire or Thread*
Mechanical	Vertical and Lateral Recordings	Edison Cylinders (Vertical)	Dictaphone System	Tefifon System (Philips Miller Recording)	Children's Toys
Optical	Experimental	Time of Day in Telephone Systems	?	Sound on Film (Cinema) (Philips Miller Reproducing)	?
Magnetic	Dictation Machines	Sound and Computers	Dictation Machines	Standard for Sound Recording	Has been used for Sound Recordings
Thermal	?	?	?	Experimental (General Electric)	?
Electrostatic	?	Experimental	?	Experimental	?

principle/vehicle combinations listed. The principles are listed in the approximate order in which they have been utilized so far in the history of the art and science of sound recording. There are one or two inclusions in this list which are, however, of more than ordinary interest because it is possible that they will soon see applications in practical technology. One uses a thermal recording method. The General Electric Company announced recently a method of bombarding electrons onto the surface of a plastic material and thus encoding information on it. The second method uses electrostatic storage of information, and this seems an even brighter possibility. At the time I drew up this table, no one foresaw any such applications; but I understand that at least one commercial laboratory has made such recordings, though no other information is available at this time.

There are, therefore, three groups of applications that one can note. First, there are those applications which have already been made. These include mechanical recordings on disc (vertical and lateral); mechanical recording on drums (as in the Edison cylinders); a variation on belts (in the Dictaphone system); another variation on tape (as in the Tefifon system in Germany); and finally, on wire (as in certain children's toys). We can also cite in this first group magnetic discs (as used in dictating machines); magnetic drums (as found in some computers, and which might also be used for sound recording); sheets, belts, and tape for magnetic recording; and steel wire. Optical recording film applications used to be quite common in sound motion pictures. This is giving way in most applications to magnetic tape sound striping on films, or to the use of separate perforated synchronized magnetic film, and is somewhat less common in telephone systems in which time-of-day messages may be recorded on optical drums.

The second group would include those principle/vehicle combinations which, as far as we can see now, have no practical utility or any prospect of development for carrying sound information. These include optical discs, optical sheets or belts, and the combination of optical vehicle and wires.

The third group offers a fascinating array of possibilities for future development and exploration, and includes all the applications of electrostatic recording in all of the forms listed; and at least two probable applications of thermal recording: one is an experimental disc form currently under development, and the other a drum which is experimental also. To achieve "closure," I have filled in question marks where there are technical possibilities but no information on whether anyone has experimented in this field.

Using these facts, and the arrangement of Table 1, it should not be hard for the reader to predict what developments the next ten-year period will bring. A little more information will allow the more experienced to predict with a fair degree of accuracy what the probable success of the application will be.

Note that we have not included here any systems which utilize some triggering mechanism to release pre-stored audio information, such as player piano rolls, and the like. These lie outside our concern.

With this background, let us consider some duplicating methods, and the principles which underlie them. I like to think of these as multiplying methods.

The first technique which was widely used for copying was that developed in connection with motion picture technique which used an optical negative and, alongside it, a sound track recorded optically. Copying here was a relatively simple process which depended only on the use of a simple contact or optical printer. It is perhaps understandable then why, when magnetic recordings first became available, it was thought that they could be duplicated using some similar method. Some successful experiments were actually made using direct printing of information from one magnetic tape to another. This was done by bringing the two media together in close contact in a high frequency magnetic field; the audio information printed over from one tape to the other. As far as I can discover from the literature available, the level of the signal on the copy tape is good, but I could find nothing about the relative degree of degradation entailed. Evidently not much experimentation has been done in this area.

By far the more common method came to be that of re-recording. In this method—which is primitive, technogically speaking—one machine is used as the master reproducer and another machine is used as the copy recorder. Such copies can be made at normal speed, or they can be made at a higher speed. There is another method, however, which has become more popular. This consists in taking the information from the first, master, recording; providing sufficient amplification to drive several loads; and then to split the information over several parallel channels. Each channel then feeds a copy recorder, and the repetition can be made, as before, at normal speed or at increased speed.

Refinements of the method have not been forthcoming, for a variety of reasons. Neither has any one explored fully the possibilities for interlacing of information between successive transmissions over the lines of usual audio data. We mention this here, however, to make our census complete.

We can analyze easily the limits imposed on us in applying the principles of re-recording. One is due to magnetic losses. If we feed information into the recording head with constant current for all frequencies, we can tell on reading it back that the characteristic registration of the sound information is a curve which is proportional to the change in flux $(d\phi/dt)$, and increases at the rate of 6 db per octave (see Figure 1). At the "turnover" point, all sorts of magnetic losses take place; after this maximum in the response curve, we find a decline, then a sharp dip due to the gap function. This phenomenon is encountered in any recording method. We know that the output in this region is given by the function $\sin(\pi l/\lambda)/\pi l/\lambda$ in which λ is the recorded wavelength and l is the length of the magnetic gap. The first minimum occurs at the point where l is equal to λ, as we can predict from purely geometrical considerations. Actually, in practice, this occurs somewhat earlier than predicted.

Now, taking the recorded signal off the tape is accomplished with standard techniques to equalize for the frequency response described. The only unfortunate result is that the signal/noise ratio varies, depending on

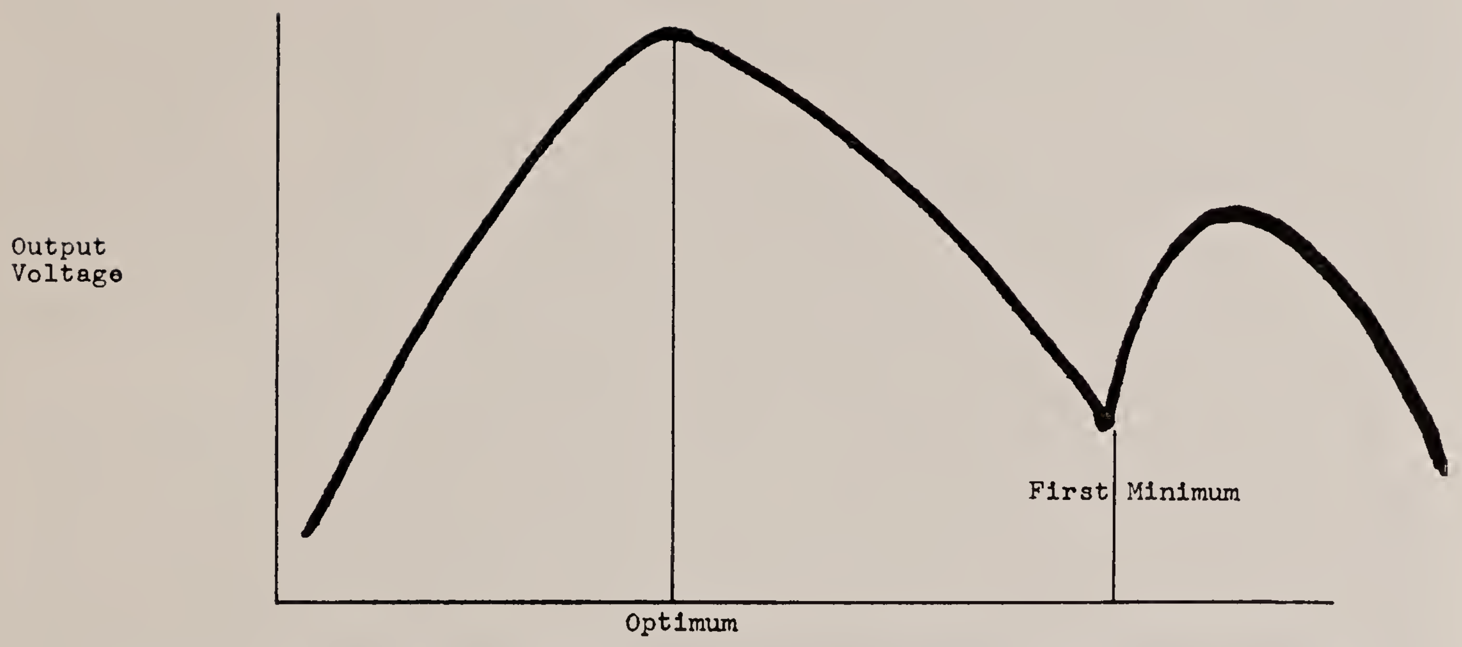

FIGURE 1 Characteristic Curve for Sound Recording on Tape—No equalization

what portion of the frequency spectrum is examined. It is obviously desirable to keep the noise level at some optimum over the whole frequency range of interest in the recording. For this purpose we have to provide equalization of the response for the range at which the gap function takes over, and (though it is seldom reported in the literature) we must also take account of the other gap function, which occurs between the total width of the magnetic structure of the head and the wavelength of the signal on the tape. This leads to a slight dip at frequencies of a few hundred cycles. If an increase in speed is included in the design of the duplicating process and if all these gap dips occur at the same spot in the frequency spectrum, a very unfavorable signal/noise condition would ensue which would not easily respond to equalization.

All the methods so far considered are of course very primitive in terms all the physics of the situation. If we require a uniform motion of tape in order to avoid modulation caused by wow and flutter, our design engineers can now provide it. There are still many sins committed against the simplest rules which should be observed in the technique. Hence it is wise, when making a master tape, to use as high a tape speed as is economically feasible to achieve the best quality possible.

We find some advantages, if we insist on quality, in copying at a higher speed. Not only does this save time (which is, or may be, very important), but at the same time we achieve a better filtering of wow and flutter for relatively small rotating masses. The filtering action depends, in fact, on the moment of inertia of the flywheel, and since the filtering is dependent on the product of moment of inertia and angular speed squared $\frac{1}{2}t\omega^2$ the higher the speed, the better the filtering action in the copying process. Higher speeds are becoming ever more possible, due in part to mechanical refinements introduced by the art of video tape recording, in which tapes are transported with speeds as high as 120 in./sec. The highest practical limit for the speed-up in copying ratio seems to be, at present, 8 to 1; beyond this point, we simply do not have available now the electronics which will handle fully the information content of the tape.

Any question of faithfulness is intimately bound up with the question of how much of the esthetic content of a recording we are willing to sacrifice in the master for a particular purpose. There has never been any discussion, so far as I know, of the point at which one could "cut" the frequency range and retain semantic content while discarding some esthetic content; that is, how much "expression" is required, and how much "dramatization" we are willing to discard. It has been observed that for recordings of persons whose voices are well-known, a rather high standard of quality must be maintained, for the listener expects to hear the distinctive qualities of the speaker's voice. For most talking book applications, it might be adequate to retain articulation and expression for the purpose of ready recognition of the semantic content, aside from all other considerations. If I were to express a personal preference, however, I would favor the retention of maximal quality in the copy and let the listener ignore or not utilize what was present in the signal. I know, for example, that fully half of the talking book users in this country are over 65 years of age, and seek diversion, have plenty of time, and are not concerned with quality in the same sense that the blind professional is concerned with it.

Special problems are involved in copying from a master recorded at one speed to lower speeds. This problem is often met with in practice, and it must be said that there are only two feasible ways of avoiding the garbled and otherwise distorted tapes which result: one way is to adjust the bias frequency and current to the special conditions imposed in the arrangement; the other way is to provide a filter which will effectively cut off the higher frequencies impressed on the master tape so they will not overload the bias circuit of the machine making the copies.

Let me close this review with the mention of two problems which are as yet unresolved. The first has to do with the value of playing master tapes backwards. At one time the opinion was often encountered in Europe that the electronics of even the best tape equipment would handle sharp transients (as in speech) better when the tape was played backwards rather than forwards when a copy was generated. I could never find any real difference in the two modes of transport, myself, but I would invite any evidence from readers who have explored this question more thoroughly than I have.

The second problem concerns the best configuration of master tape and slaves or daughter tape mechanisms. There are at present two ways open to us to make copies. The first is the more common: to work with mechanically independent units by providing a sufficiently powerful signal from the master tape reproducer to drive each of the slave tape recorder copiers. The other way is, as some have suggested and as some have tried, to run off a multiplicity of tapes on the same drive shaft, using the same flywheel. The superiority of one system over the other has not been definitely established—in spite of the overwhelming preference of the first solution in the professional field. This is a matter which, I think, cannot be discussed and then dismissed, offhand, as settled.

In closing, I would like to say that although Mr. Clark gave me the task of discussing the *problems* of tape duplication, I think that in fact there is no real problem if the physical principles and the appropriate technology are both taken into account for particular applications. These two factors do impose some inherent limitations on any given system for producing copies, however, and it is necessary to take them into account in the duplicating or repetition process. Certainly the coming situation, in which the talking book will be available in several mechanically incompatible forms from the several countries producing them, should encourage us to explore these questions in detail. In making such an exploration we should also keep in mind some of the principles outlined here in order to avoid some of the simplest difficulties. We might also keep our plans open for imminent advances in the technology of duplication—even if that technology serves ultimately as only an intermediary for the production of copies across the boundaries imposed by the systems of the several countries.

COMMERCIAL DEVELOPMENTS IN TAPE CASSETTE SYSTEMS

ARTHUR KAISER
Columbia Broadcasting System Laboratories, Stamford, Connecticut

There are two points I should like to make clear before we begin. The first has to do with the kind of enclosure we talk about for the tape used in playback machine; until a short time ago, I had never heard the term "cassette" before in place of the term "cartridge," with which I am more familiar. In what follows, I trust you will excuse my substitution of the latter term in place of "cassette." The second point concerns the meaning of the term "commercial" in the title to this paper. The meaning of the term, as I see it, is in the provision of equipment which is readily available in the market and does not involve making special equipment for the blind user—or, for that matter, for the duplicating centers making talking books. Such commercial availability simplifies problems of cost and of distribution.

I should like to review in brief several types of commercially available cassette systems now in use, at least to my knowledge. The first is a system in wide professional use: the single reel, continuous loop system. This system is used for several short-term purposes, such as for spot announcements in broadcasting, or some background music applications, or for short and repeated announcements of the kind you hear over the telephone. An important variation incorporates a Möbius loop permitting the use of both sides of the tape, thus achieving twice the playing time for a unit length as compared to standard applications.

The disadvantage for the talking book system lies in the lack of consistency with the demands; that is, the playing time and the bandwidth requirements are not consistent with this type of system. The talking book system requires about 600 feet of 1 mil tape, and this length of tape, in one continuous loop, would require a rather complex drive system, different from those now in use. In the common type of endless tape system the tape is drawn from the inside diameter of a single reel and replaced on the outside diameter, in a fairly simple manner. Since a certain amount of sliding friction is involved, the tape must be specially lubricated. The lubricants required generate certain problems over the long term and can damage heavily the magnetic heads of a tape deck. For these reasons, we did not feel that such systems represented a practical application to the talking book.

The tape cartridge developed by the Radio Corporation of America (RCA) is the first example to come to mind of the practical kind of cartridge which was designed from the outset for consumer application. The cartridge is now being manufactured. It consists of two small diameter reels within a plastic container which are wound with 600 feet of one-quarter inch tape. In the RCA application, the cartridge is designed to record and play back four tracks of monophonic or stereophonic recordings. Each track is 45 mils wide. The system as designed by RCA is intended for playback only in the home at 3¾ in./sec tape speed. All that is required by the user is to push the cartridge into place on the tape player, whereupon the necessary capstan, pressure roller, and head are all engaged.

The disadvantage of the system for talking book application lies in the fact that, since this is a special type of cartridge, it will require special types of duplication equipment for copying at high speed. Since the copying for the talking book is intended to be carried out at professional recording centers, it would not be feasible to utilize the common consumer playback equipment for the purpose, for it is not rugged enough for this purpose; this is so in spite of the fact that such playback equipment is beginning to appear at modest prices for the consumer. In addition, the consumer deck is neither provided with, nor adaptable to, remote operation, and remote operation is important in professional practice. We can conclude, therefore, that the use of a cartridge like that made by RCA would mean undertaking the engineering of a good duplicator—unless it was planned to take the tape out of the cartridge while it was being duplicated. For these reasons, we did not feel that this type of unit represents a practical solution for limited production runs.

There was a third type of cartridge originally intended for consumer use, however, which has certain attractions for the talking book application. This was developed by CBS Laboratories for the Minnesota Mining and Manufacturing (MMM) Company, and has been described in the professional journals in the form developed for the consumer high fidelity market. The design of this system is somewhat different from those mentioned before. The most important difference is that the cartridge contains only the supply reel. In other words, the tape does in fact leave the cartridge in operation, and follows what we might call a "free" path. The cartridge is, however, self-threading: the user has only to push the cartridge in place, push the "start" button, and the tape, which is preceded by a long and rather stiff leader, threads itself through the mechanism. The machinery for accomplishing this has been worked out over the last few years by a combination of concentration, first from CBS Laboratories, then from the MMM production facility. The tape path to the take-up reel is not touched at all by the user, for the path is actually blocked to the fingers of the user. The cartridge was originally designed for a tape speed of $1\frac{7}{8}$ in./sec; contains 600 feet of 1-mil magnetic tape; uses tape 150 mils wide (60 percent of the width of standard one-quarter inch tape). Three tracks are accommodated in this width, each of 45 minutes in length. The original design was for high quality sound reproduction. This system was in fact designed to compete with the long playing record in terms of quality, playing time, and cost; the equipment made for it is capable of reproducing frequencies as high as 15 kc/sec.

In its talking book guise, the design is modified somewhat, both for the production of copies and for reproducers. It is expected that MMM will announce the availability of the reproducers in the Fall or Winter of 1962. The impetus for the adaptation to the talking book was given by a joint undertaking of Recordings for the Blind, Inc., and the Library of Congress, who last year asked CBS Laboratories to develop a high speed duplicating equipment for the MMM cartridge, and to modify the commercial cartridge reproducer to permit the change to a tape speed of $\frac{15}{16}$ in./sec.

The first half of this program has now been completed; this concerns the high speed duplicating equipment. The second half is not yet completed since it must be timed with the production engineering of the reproducer.

The balance of this paper will be devoted to a description of the main design concepts realized in the high speed duplicating equipment. In its essentials, the copying process is as follows. A master tape is recorded on a two track, one-quarter inch wide tape at $3\frac{3}{4}$ in./sec speed; it is contained in a 7-inch reel. This tape is referred to henceforth as the "unit tape," and comprises the recorded material with which the reader is ultimately supplied. At the end of the recorded portion of each reel of unit tapes a piece of silver foil is fastened (either by an editor or by the reader himself). The reels are then taken to the duplicating center where they are run off at 16 times their normal playing speed (i.e., 60 in./sec) on a master reproducer which feeds one to ten slave reproducers which utilize a tape speed of 15 in./sec; all the cartridges are recorded simultaneously. Any number of copies up to ten can be made at the same time.

From this point forward, all further copies are made from these "submasters" recorded from the unit tape. Up to ten copies at a time can be made from the submasters, with all three tracks being impressed at the same time.

The duplicating center consists of one master reproducer using 60 in./sec tape speed; two submaster reproducers using a 15 in./sec tape speed, and ten slave recorders. All three reproducers may feed into any combination of recorders; virtually any combination is possible.

Figure 1 shows a block diagram of the signal paths of the entire duplicating center. The signals involved may rise as high as 80 kc/sec in this system. The reason for this is that when copying is done at 16 times original recording speed, the entire spectrum is translated by that order of magnitude as well. Thus, a tape master recorded with a bandwidth of 100 cps to 5000 cps requires a bandwidth of 1600 cps to 80 kc/sec when the copying speed is 16 times original recording speed. It is also obvious that 60 cps hum components become relatively unimportant since, when played back at $\frac{15}{16}$ in./sec, this frequency is translated to $3\frac{3}{4}$ cps, which is completely inaudible (even if the reproducer could reproduce that low a frequency—which it cannot). There is therefore a very wide tolerance for using a free hand in the design of the equipment and the circuitry as far as ripple, hum, and the like is concerned.

Each slave duplicator has a signal selector by which it can choose the source that will drive it. It can chose from among the master reproducer or either of the two submaster reproducers; the choice is made from the slave recorder location. There is also an "off" position of the selector; when the unit is switched to this position it is operated for maintenance purposes only (i.e., without remote control). The master reproducer uses the 7-inch unit tapes running at 60 in./sec through a reproducer amplifier. (This unit, and all the others in the system, are Ampex professional units that have been modified for this service.) After going through the reproducer amplifier, containing the necessary reproducing equalization, the signal is fed to an attenuator to adjust level, and then to an automatic gain control (AGC) device serving a very important function. We may assume that many of the unit tapes will have been made at $3\frac{3}{4}$ in./sec on equipment which is most often of much less than studio quality (as when volunteers record on small portable machines), and that level variations will occur in the speaker's voice level from tape to tape. CBS Laboratories has developed recently a device called the "Audimax," a product intended for broadcast and recording studio use, which eliminates former objections of these users to level control devices. We have therefore modified this system to

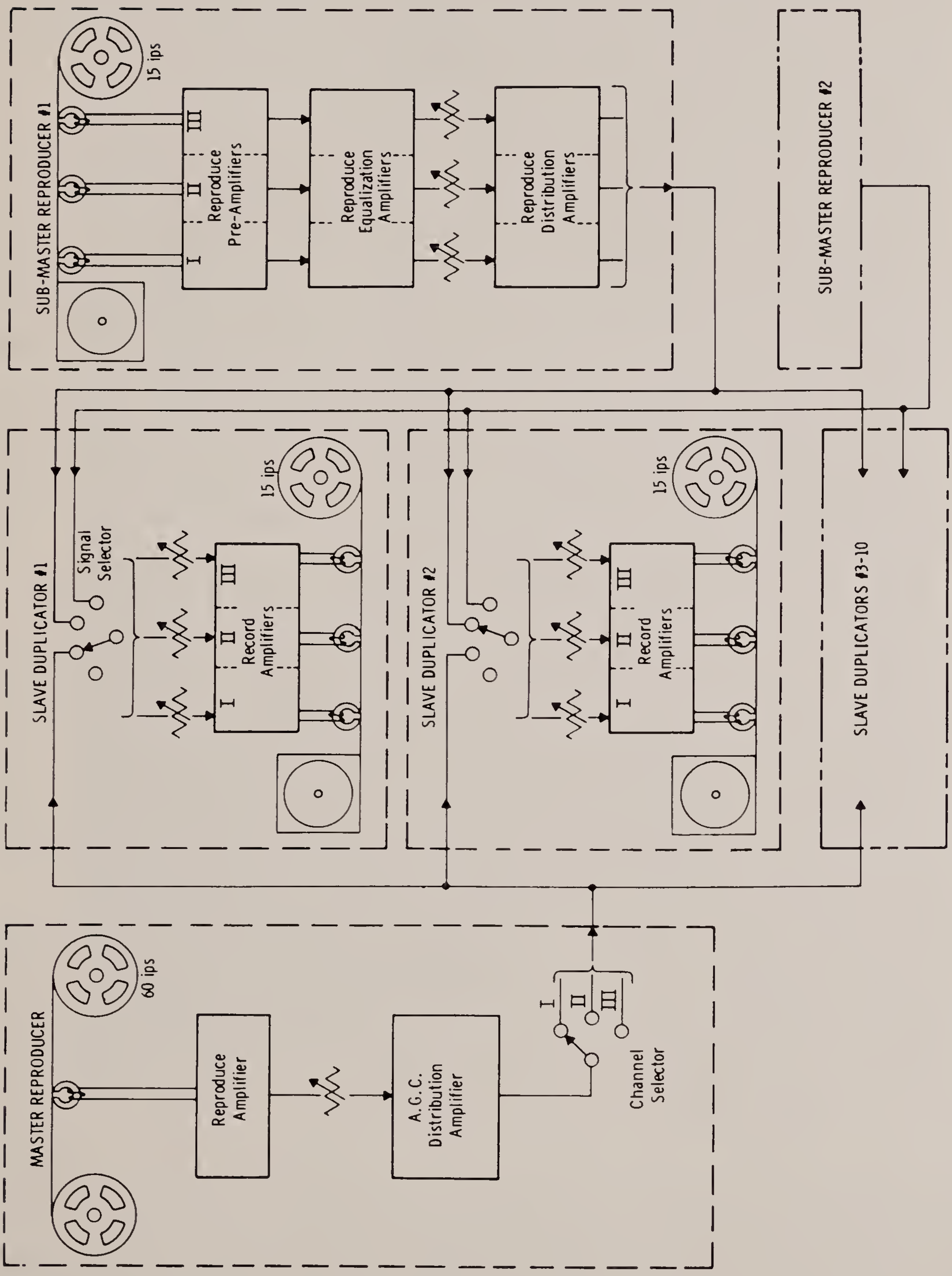

FIGURE 1 Block Diagram showing Signal Paths of a High Speed Tape Duplicating System

accommodate a bandwidth of 1600 cps to 80 kc/sec instead of the audio range. In the high speed talking book duplicator, this Audimax system serves the function of providing a constant output from the distribution amplifier. Furthermore, we already know that if we utilize the range of control provided by the AGC control, we can allow up to 20 db variation in level in the unit tapes and submaster tapes, and still end up with the same, normalized, level in the distribution amplifiers.

Next we select the particular channel of the cartridge which is to be recorded. In recording from the unit tape, only one channel is used at a time for making submasters. As switching is made from Channel 1 to Channel 2 to Channel 3, the signal and its appropriate bias current is automatically applied to the correct head of the recording slaves. The slave systems thus employ three heads; have three separate record amplifiers; and are equipped with locking attenuators for adjusting and fixing levels once for all. You will recall that the three tracks have been recorded sequentially on the submasters, and that they are taken from the master reproducer and from the submaster reproducers to as many slave recorders as we choose.

When recording from submasters to the final talking book, the prerecorded cartridge is placed on the submaster reproducer. There are three tracks on the cartridge which are repoduced though the reproduce amplifiers; these latter are very low noise transistor amplifiers. The signal then goes to the reproduce equalization reproduce amplifiers (also three channel), through the reproduce distribution amplifiers which incorporate control for matching the levels out; in this way adjustments to the source level feeding the slave units are never required. You will recall that the choice of source is made at the slave units.

Figure 2 is a photograph of a portion of the system. We noted above that the basic duplicating center consists of one master reproducer, two submaster reproducers, and ten slave units. Although the center provides for this many units, not all of them have been actually provided as yet. At present, the system includes one master reproducer, one submaster reproducer, and additional electronics to provide for another submaster reproducer; all controls are provided for the additions. The present system also includes two slave units with tape decks and amplifiers.

Figure 3 shows a block diagram of the duplicating center. Here the emphasis is on the control logic rather than on signal pathways. In the slave duplicators, all action is controlled for running the tape by the pressure roller solenoid; the feed for all the pressure roller solenoids is a power supply common to the entire system. It provides approximately 100 volts

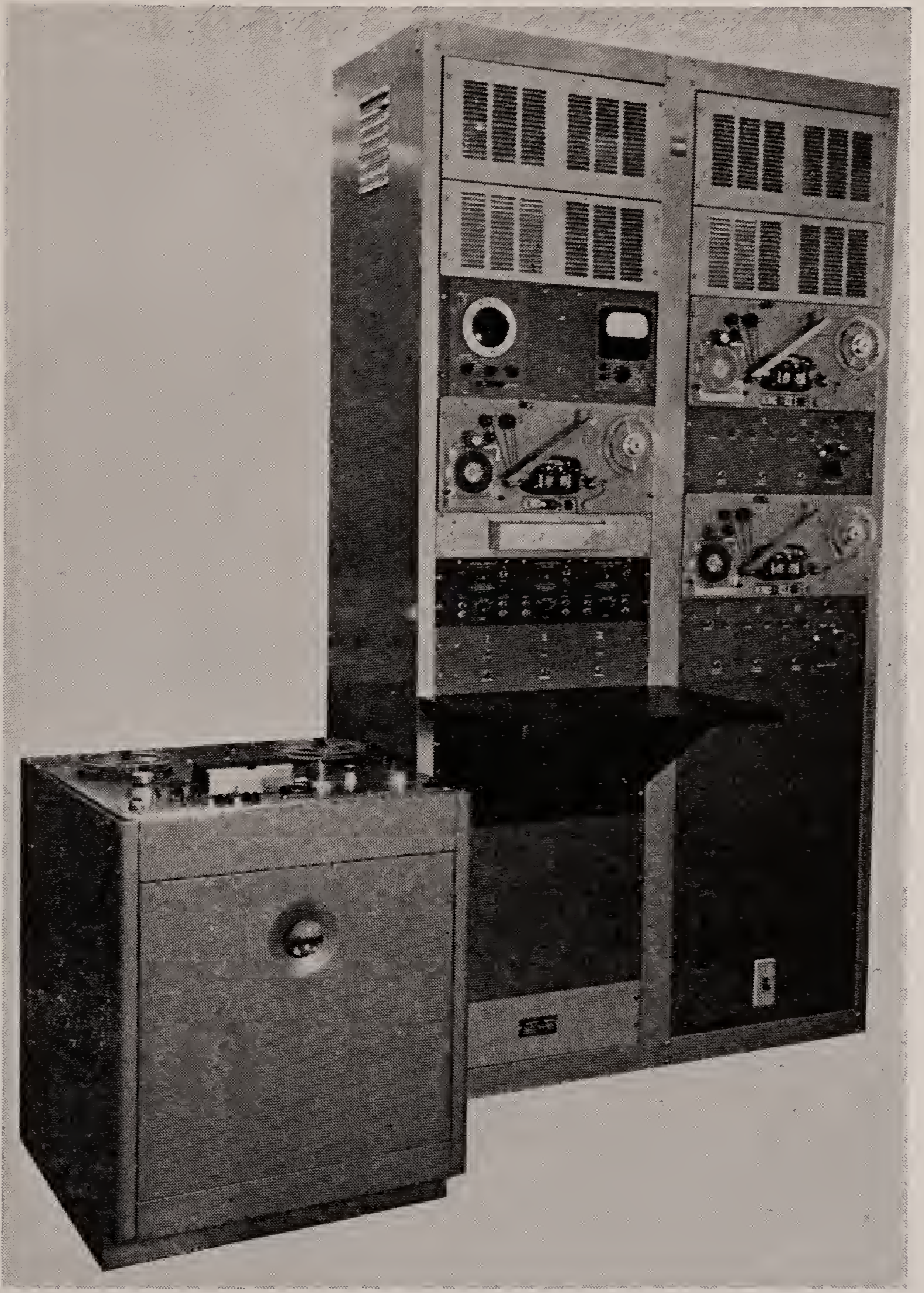

FIGURE 2 A Portion of the Complete High Speed Duplicator

dc to activate the solenoids. In order for the solenoid to operate, a continuous loop must be made through the power supply to any one of the solenoids which have been selected by the source selector on the slave units which are fed from the common source. Assume, for example, that we consider slave units only which are all set by selector switch to one source. In preparing for a recording run, the operator must satisfy all the various conditions evident from a glance at the photograph of the equipment be-

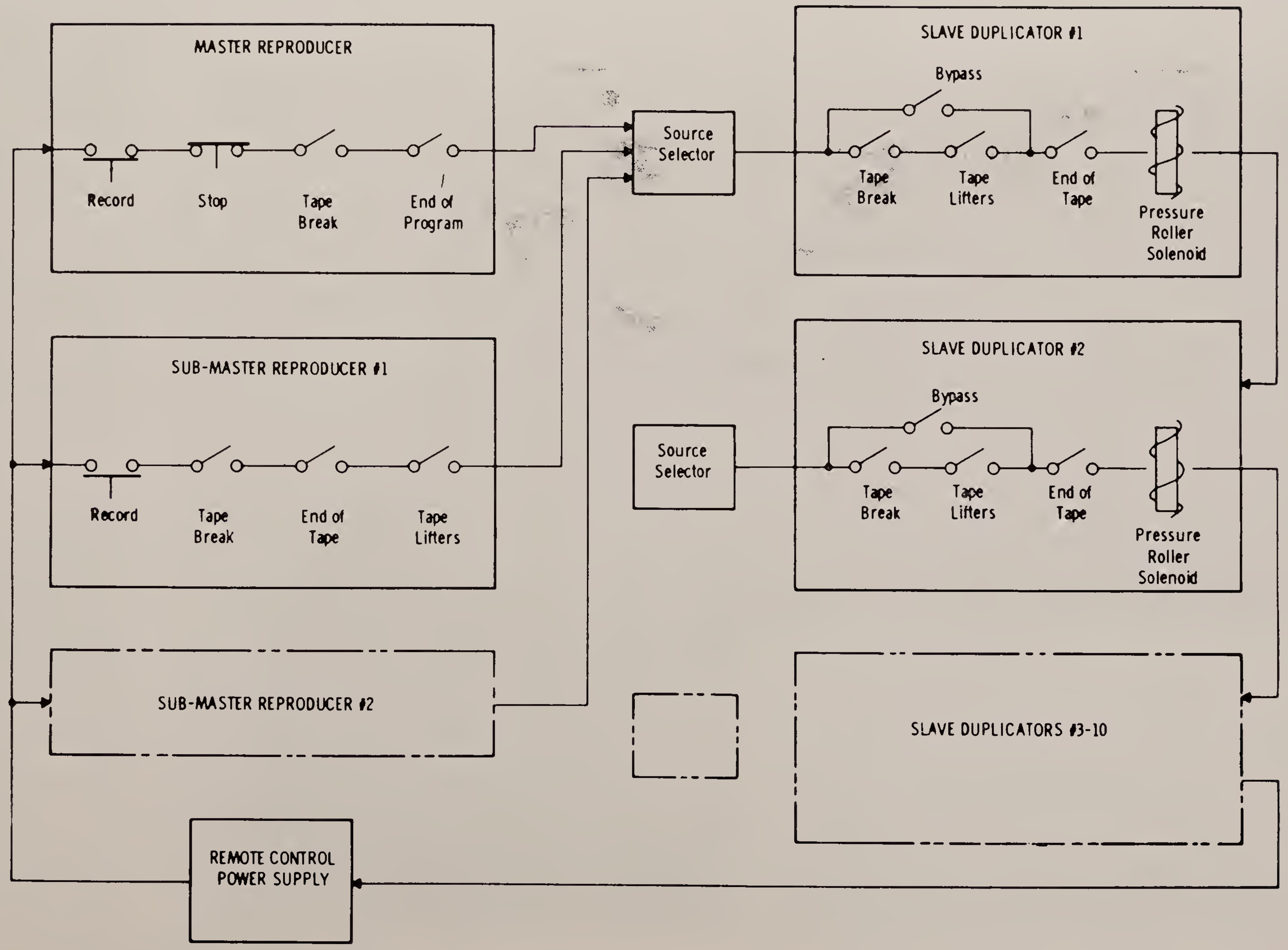

FIGURE 3 Block Diagram of Control Logic of the High Speed Tape Duplicating System

fore the mechanism can be started. There is no danger, therefore, of a "false start," in which the master reproducer is turned on, the slave is supposed to start, but the tape lifters have been left "on" to allow for rewind, and no recording is possible.

If the submaster reproducer is selected as the source of signal, the same form of logic obtains. All control of the slave units is such that the record button on either the master reproducer or on one of the submaster reproducers starts the slave units all at once. We have also built into the system a scheme of "ready" lights to inform the operator when all the conditions are satisfied for proper operation. A quick glance at the master reproducer will show him whether the "ready" light is on and he is set to record. If the light is lit, he presses a button and the recording process begins without further attention.

Figure 4 shows a close-up view of the basic slave recorder group, con-

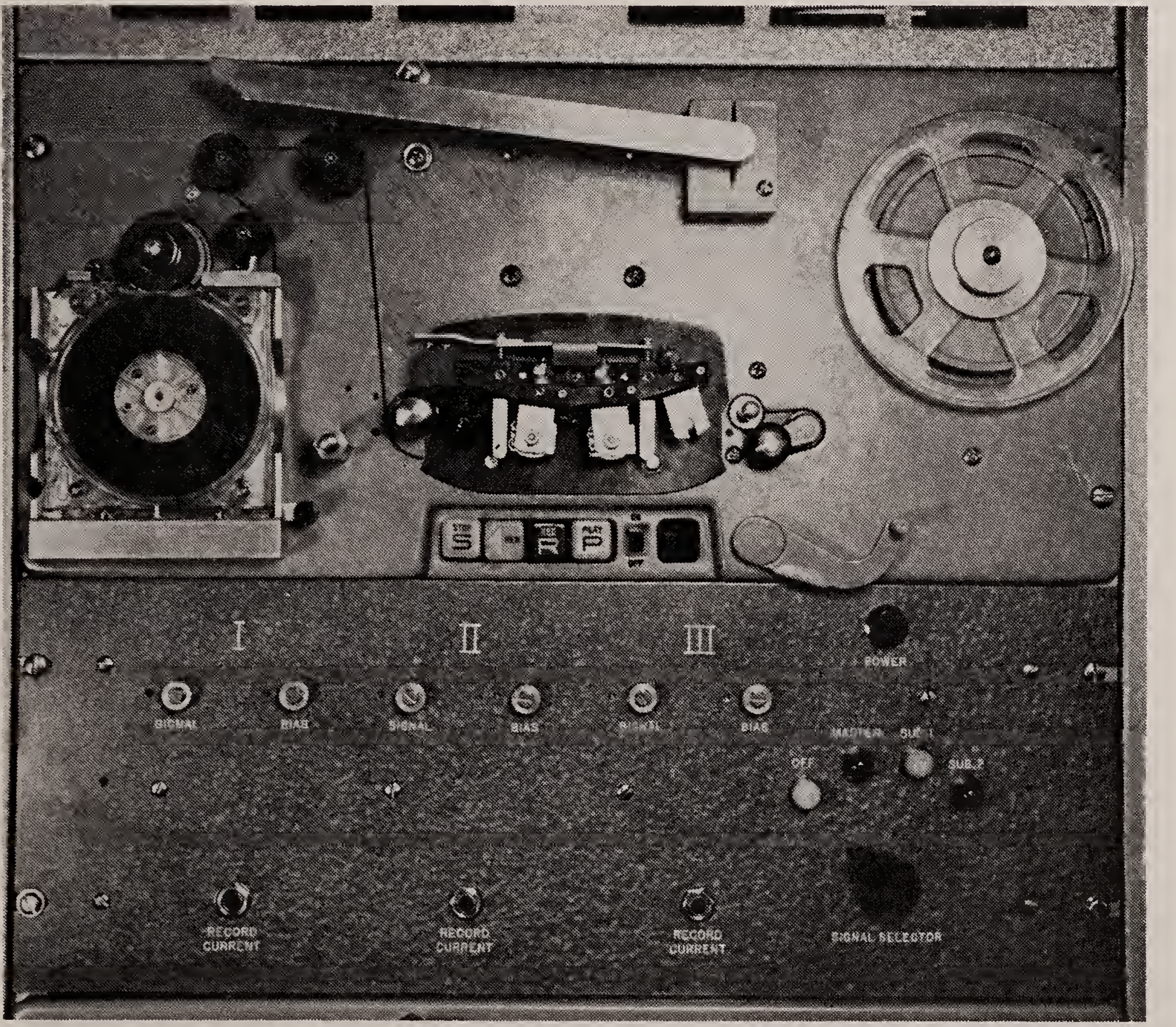

FIGURE 4 Close-up of the Basic Slave Recorder Unit (Rim Driven Tape Cartridge on Left)

sisting of a transport deck on the top and a three channel record and bias amplifier below. Note that in the photograph a cartridge is shown in its holder on the deck; the tape within it is threaded to follow a path past the heads and onto the take-up reel. The head assembly of the deck is modular; it can be removed as a unit for maintenance purposes without danger of misalignment, and it can be replaced by an identical assembly in case of damage. There is also a tension sensing arm on the deck; I shall return to this in a moment. To the right is a tape break switch common to the Ampex PR-10 unit on which the present unit is based. There is also a tape lifter for high speed rewind that lifts the tape away from the head assembly. The amplifier (of which you can see only the front panel in this photograph) incorporates controls for signal and for bias; these are set once and locked, for no further adjustment should be required. There is also a monitoring jack for checking the record and bias currents with an external meter included in the system. There are also four colored lights which indicate the

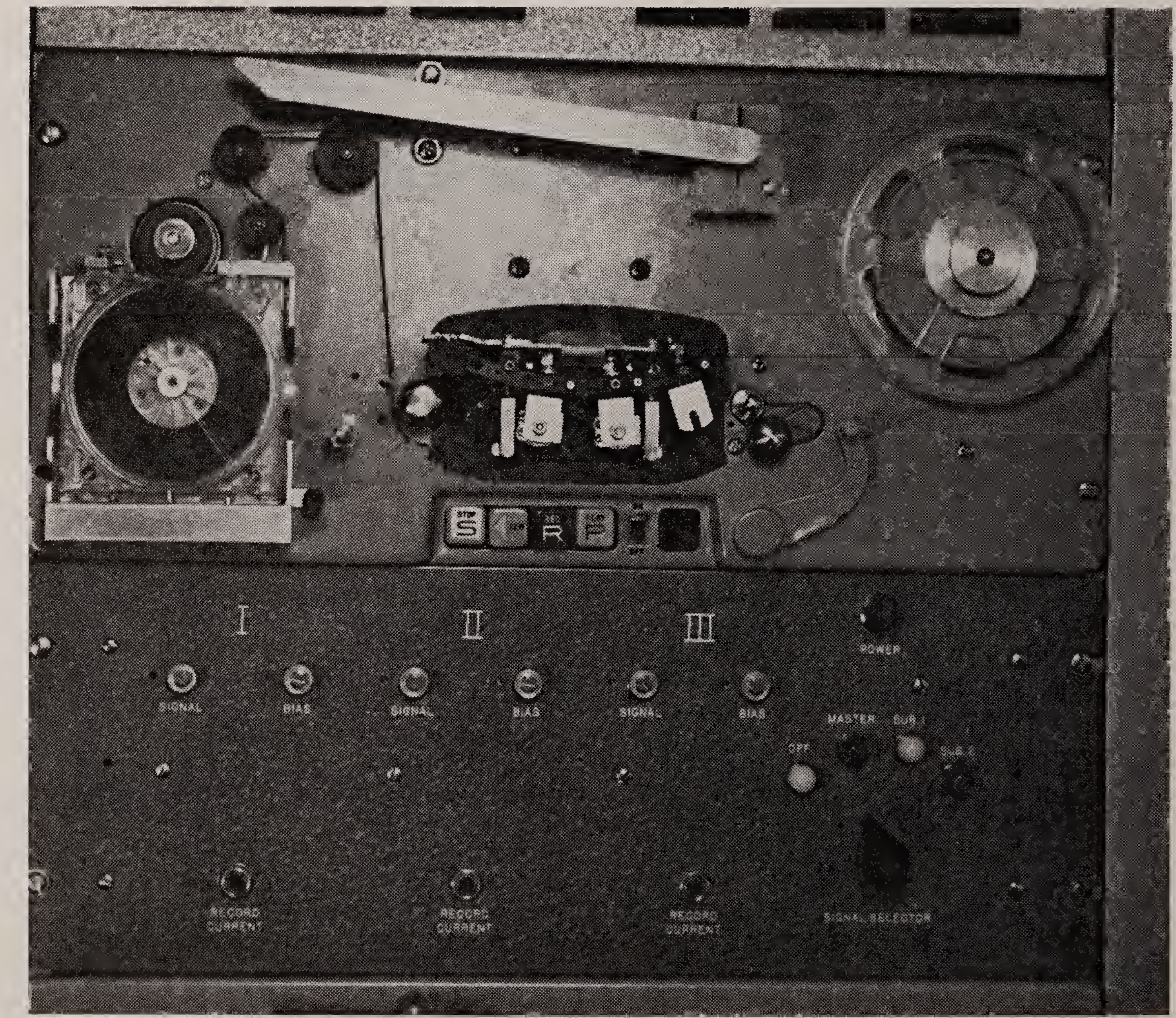

FIGURE 5 Close-up of Slave Recorder Unit Showing Tape Threading Path

position of the source selector switch. If, for example, the selector switch happens to be at the "master" position, a blue light will go on and will identify which slave recorders are operating from this source.

Figure 5 shows the same slave recorder, but this time with the tape threaded through it. Note that the tape break switch is lifted and that the tension sensing arm is up. If the tension sensing arm were yanked down it would catch the tape with a small rod extending backward normal to the deck surface, and it would pull the tape down to a "rest" position.

In Figure 6 the final rest position for the rod can be seen. The tape follows the path shown, through the idler and past the heads. When all the tape in the cartridge has been run off, the end is held in place by a strip of plastic trailer which allows the reel to keep spinning. At this point the tension on the tape causes the arm to be pulled up. When the arm is lifted up, the entire system will stop. The first slave recorder to reach the end of its tape will cause the entire system to stop. Then the tapes must all be rewound; this takes about two minutes. If the recording is being made from a three track submaster the run is finished.

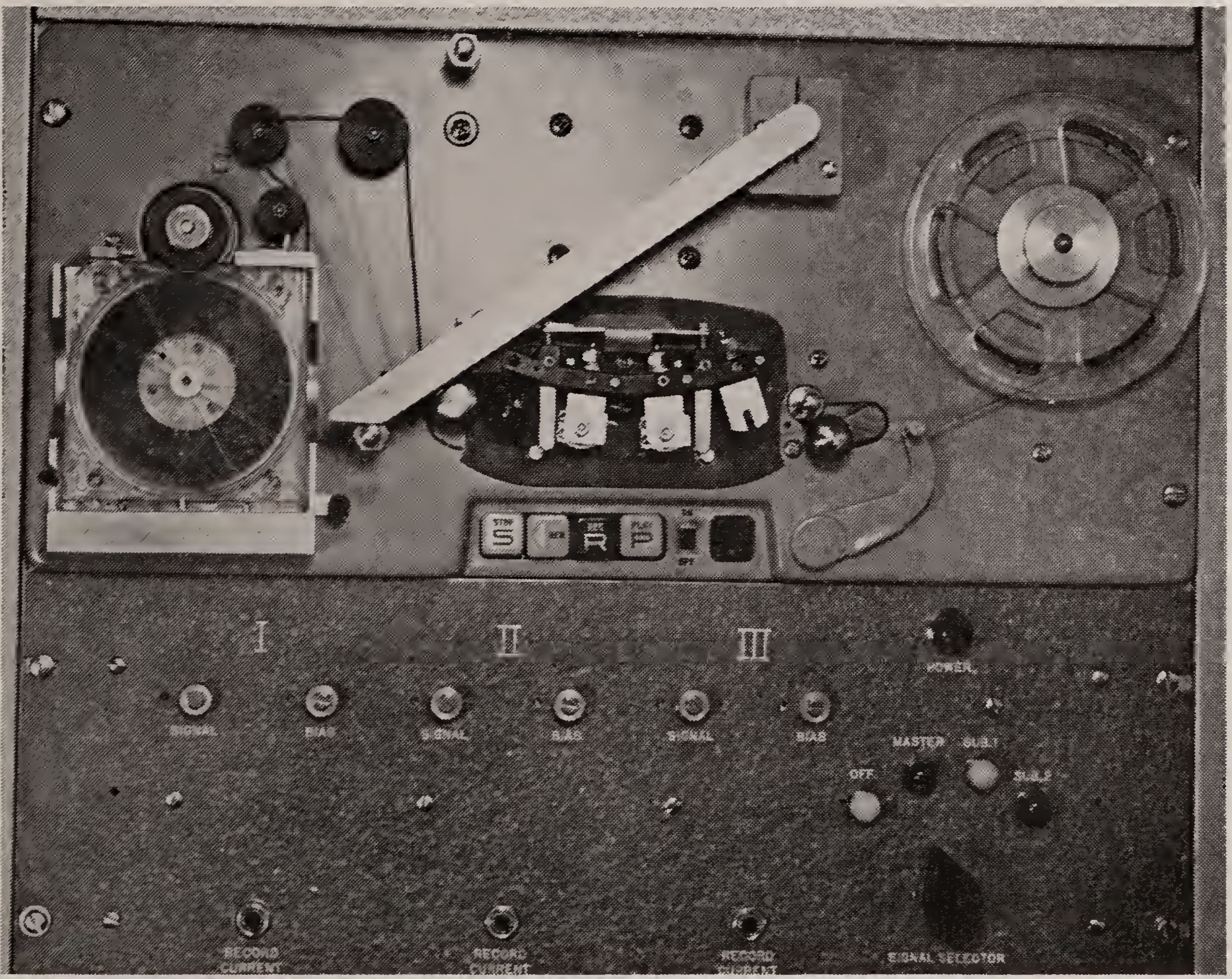

FIGURE 6 Close-up of Slave Recorder Unit, Showing Final Rest Position of Tension Sensing Arm

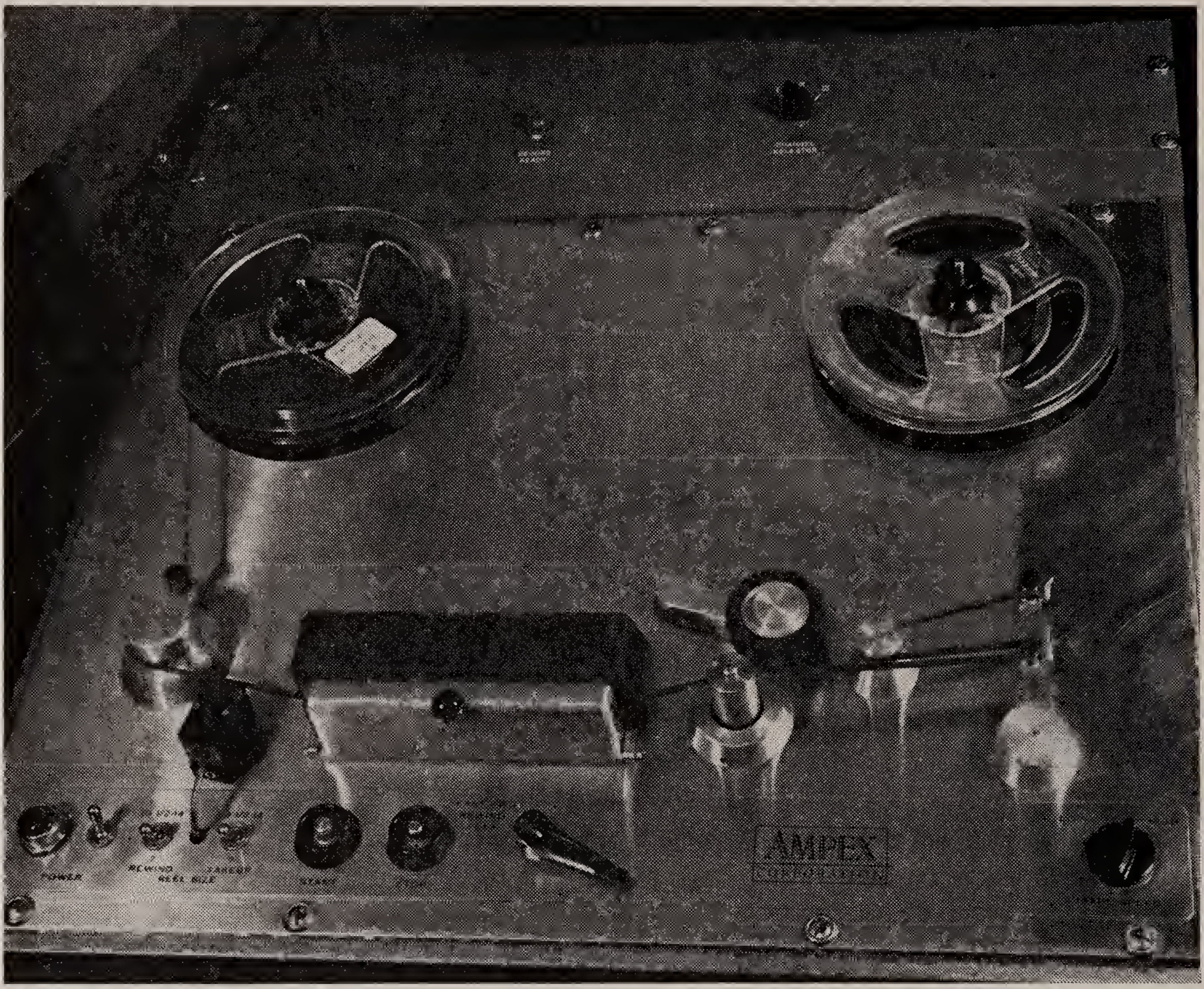

FIGURE 7 The Master Recorder Tape Deck

Figure 7 shows the deck of the master reproducer. To the right is the tape break arm which stops the entire system if the tape should break. At the top is the record ready light indicating, when it is lit, that every condition has been satisfied before recording is begun. At the right of the top panel is the track selector switch, with three positions.

Figure 8 shows the interior of the master tape console. The reproduce amplifier and the AGC distribution amplifier are housed in this unit.

Figure 9 depicts the whole group, consisting of the submaster reproducer, the three channel transistorized preamplifier, the three channel equalization amplifier, and the three channel distribution amplifier with monitoring jacks at many points in the chain for ease of maintenance. The tape deck is the same type used for the slave recorders; the only difference is that there is no recording "ready" light. The preamplifier is mounted outside for maximum cooling. At the top left is an all purpose signal generator; this is used as a bias oscillator when beginning recording, and to feed a bias distribution amplifier which can be monitored and tuned in recording.

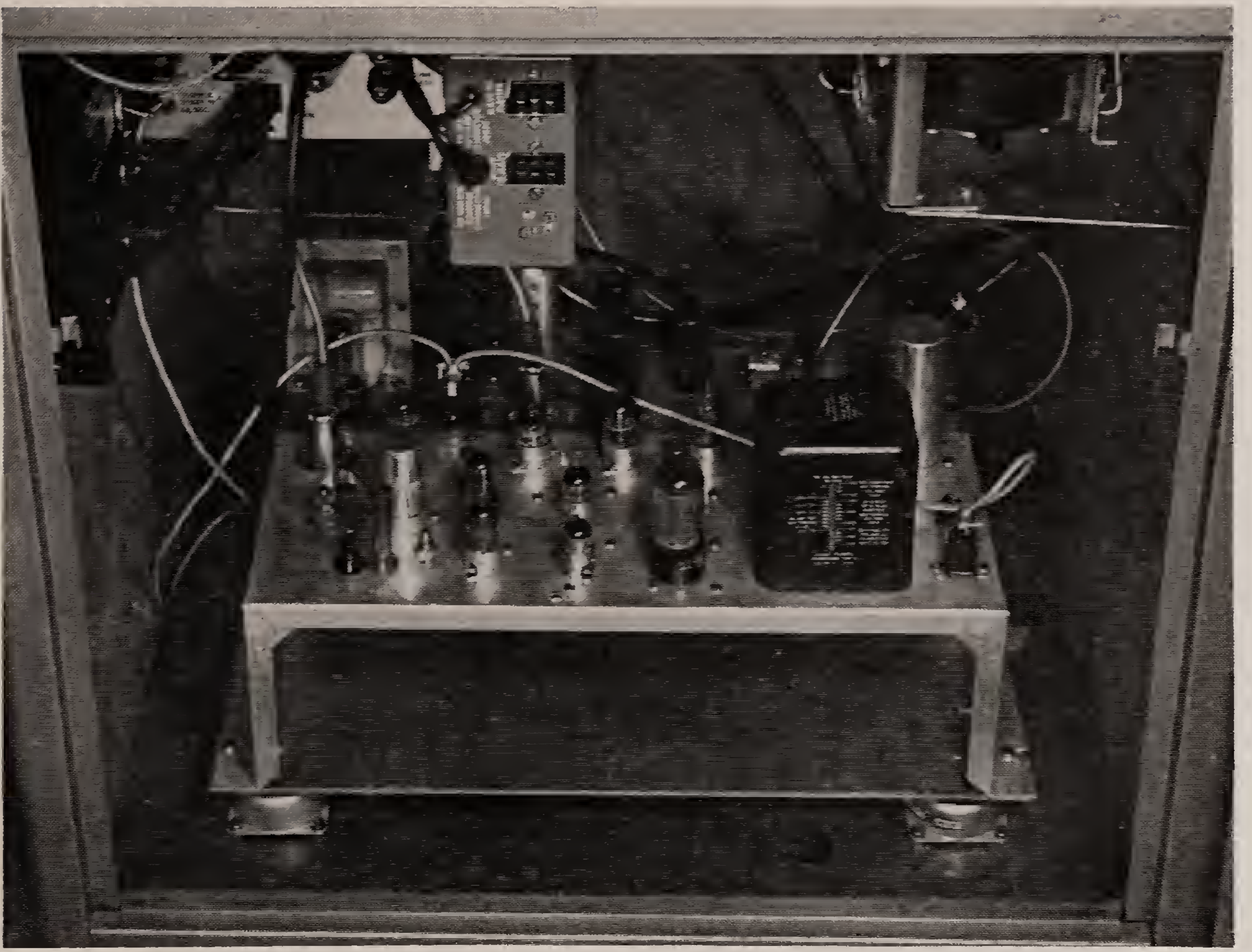

FIGURE 8 Interior of Master Tape Console Showing Reproduce and AGC Distribution Amplifiers

The bias frequency is a half-megacycle. A vacuum tube voltmeter is used as a signal level monitor; this is possible due to the fact that at 16 times normal speed of speech a fairly constant signal level is obtained which is easy to check for consistency.

A few figures concerning the operation of the system may be of interest. The playing time of the talking book cartridge, using a tape speed of $\frac{15}{16}$ in./sec is six hours. Each of the three tracks is played in sequence, with a two-hour duration for each playing. In production, it takes eight minutes to record three channels simultaneously, and two minutes to rewind the tape and take it out. At this point the cartridge is ready for mailing.

The cartridge itself is rim driven; the threading operation in the user's player is automatic: once the cartridge is inserted into the player, a wheel grabs the rim, starts it, and the tape leader threads itself, catches the take-up reel, and the player begins the book. In the duplicating system, the threading is done by hand; I would say that it takes an average operator all of five seconds to run the leader through the machine. It is really no trick to thread the very stiff leader through and catch it on the take-up reel.

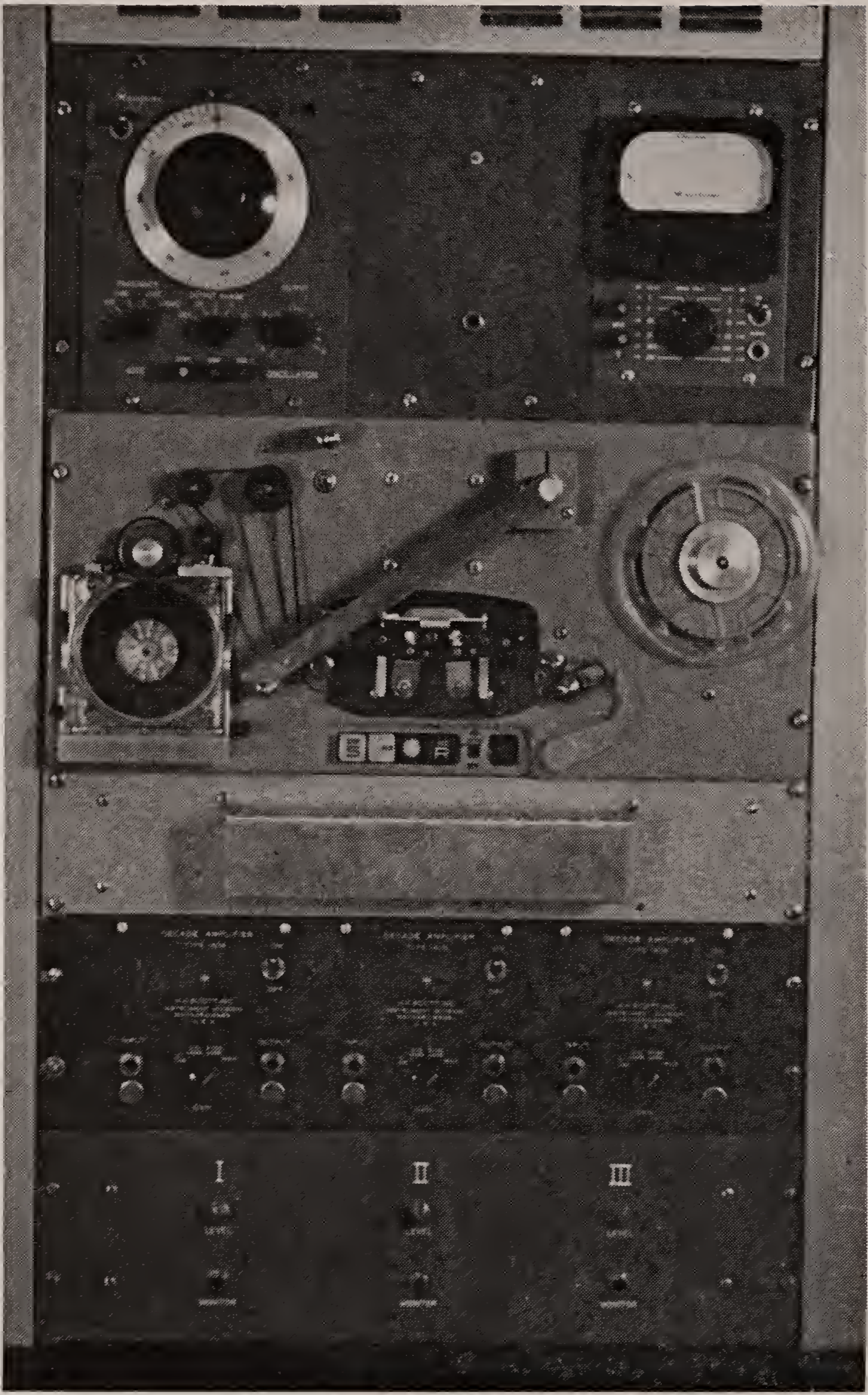

FIGURE 9 View of the Complete Slave Recorder and Electronic Circuit Panels

In operation, let us assume that we start with a six-hour unit tape. Using ten slave recorders it is possible to produce 500 cartridges in one ten-hour period; this is a conservative estimate. This much work could possibly be done in as little as six hours. This means 500 cartridges in ten hours, or five cartridges per hour per slave recorder. This is a production speed-up ratio of 300 to 1, based on the total playing time of the cartridge versus the ten hours it took to make them. Much of the control logic of the entire system has been designed by keeping well tried principles of human engineering in mind. In describing the system, it may of course seem complicated the first time around. Let me assure you that in actual operation, the system can be attended to very easily by one man—who need not be a technician; he could as well run off three different programs if need be.

The provision of a sufficient number of tape players will be the final element needed, I would suppose, to show how useful a system this can be, especially in field trials. I should point out, however, that CBS has been involved in the designing of these components for itself and for MMM since 1958. A vast backlog of engineering experience has been acquired in this work so that in our design for the talking book version for the Library of Congress, we were able to draw on what amounts to a heritage of knowledge and experience from earlier work. Furthermore, much of our ability to achieve satisfactory recording and playback at the very short wavelengths represented by a tape speed of only $\frac{15}{16}$ in./sec is dependent on the availability of very high quality, narrow gap heads. This technique has been a research and development specialty of CBS Laboratories and was, I would suppose, the main reason why we were able to do this job satisfactorily.

Even with a uniform playback response or bandwidth of from 100 cps to 5 kc/sec, we have been able to maintain a signal/noise ratio in the vicinity of 45 db on the third generation tapes. If one considers the fact that this represents no more than a 3 db degradation in the signal to noise ratio over each of the recording steps, and that this is no more than one would expect even if no signal were transferred at all, then you can appreciate our pride in the system.

PROJECTED COST ANALYSIS FOR A TAPE TALKING BOOK PROGRAM

ROBERT S. BRAY
United States Library of Congress, Washington, D. C.

In the papers presented so far the reader has had the opportunity to explore many technological developments. I think he will also understand why most bureaucrats sooner or later get ulcers. The Chairman has asked me, once again, to go out on a limb; and he now also asks me to go out on a limb and look into the future from the end of that limb—which is a neat trick! It is clear that as the current Cook Laboratories and Columbia Broadcasting System (CBS) Laboratories develop further there will be some careful consideration of the future of tape talking books, not only by my own staff but also by specialists upon whom we will call.

To analyze the projected costs of a tape talking book program, there are twin terms on which we can base our thought. The first is the kind of cost accounting experience we have had to date; this is often fragmentary, as we have learned, not only in terms of actual experience but also in terms of an industry which according to its own members is somewhat immature. Second, any projection must be made in terms of the demonstrated capacity of discs; tape must not only compete favorably with discs but must prove itself demonstrably superior to them. It is the analysis in these twin terms with which I would like to explore the question in brief.

Let us consider first the tape playback device. We know from many years of experience that a reproducer for discs which is both rugged and of high quality costs about $35 per unit when made in quantities of tens of thousands. In spite of extensive exploration of the possibilities for simplification in a tape reproducer, we have been unable to reduce our estimate below a cost of about $60 per unit. This is, of course, approximately twice the unit cost of a talking book disc reproducer.

As for the use of magnetic tape, there are certain similarities to compare with discs. The studio time costs are now, and apparently will be in the future, essentially the same for discs or tape, unless volunteer readers are employed to record the books. Even volunteer readers involve some costs, however, for they have to be found, they have to be trained, they must be provided with tape, and they must adhere to some a priori set of quality standards. Thus the studio costs, with which we can combine the just-mentioned costs, will be very similar for both systems.

For the raw materials, we must include the cost of a cassette loaded with virgin tape in order to compare it with a normal playing time of a given record compound weight, and the former will make tape cost more than disc recordings. How much more we cannot determine with precision; nor was I able to notice any comparison on this basis among the papers presented here.

The duplication of copies in large quantities does not lower the unit cost, apparently, in tape based systems. It would seem that any proposed tape system will be a very sophisticated development indeed to compete (much less win) against the simple, "biscuit cutting," technique used in disc production. There are a few economies which can be derived from the use of tape, however, and they must be measured and evaluated in any projection of costs. We have considered a few; they are: the long life of each copy of a book title; the flexibility in producing as many copies as needed at any given time; and the re-usability of the recording medium when its topical importance has ended.

We have had a little experience with actual tape costs in the case of the Radio Corporation of America (RCA) tape cartridge (cassette). Additional evidence will be derived from our field tests currently under way. If we start with a master tape of one 8-hour book which is contained on one reel of a single track recording, an intermediate master will occupy two RCA cartridges. We will be charged about \$10 per hour, or a total of \$80, for dubbing, duplicating, and otherwise preparing the tape. In quantities of 25 copies, the RCA cartridges could be loaded and recorded for \$2.80 each. An 8-hour book that occupies two of these cartridges will thus cost \$5.60.

We have also had some actual experience upon which we can draw: our ongoing tape program. Here we use standard commercial tape; a tape speed of $3\frac{3}{4}$ in./sec; a reel 7 inches in diameter containing 1800 feet; 1 mil tape; two track recording. A 9-hour book recorded under these conditions will cost \$2.36 per reel, or \$7.08 for the first copy. When 6 copies are made at one time, the costs per copy including labor were a little more —\$7.28. This per copy cost figure does not include shelf storage boxes of very simple design and made of cardboard; these cost 35 cents each. Mailing containers cost \$1.20 each.

Now let us consider the second of the twin terms of which I spoke above. This concerns the demonstrated efficiency of discs versus which the tape medium must not only compete, but must prove substantially better. In spite of all the asserted inadequacies in these discussions of discs, the disc talking book program in this country, in fiscal 1961, circulated 2,001, 227 containers to 60,368 readers. Indeed, it is not unusual for a regional library to send out 1000 books in a single day.

Let us say, then, that in comparing cost units per book copy, tape *may* compare favorably with discs in *most* segments of the talking book system. The cost of the reproducer might be reduced to approximately $35; tape contained in cartridges or cassettes like those of CBS and RCA are made of molded plastic and thus may be comparable in cost to discs for the same playing time; the production and distribution system might be worked out so that the efficiency of both media is approximately equal. Many aspects of the tape system might thus be worked out satisfactorily—except for the problem of duplication. It is my opinion that the problems of duplication could very well determine not only the establishment or abandonment of the system; they could make or break its future for the talking book. Duplication is the essential problem.

A tape talking book program applied within the context of usage of which we have spoken here may not just exceed disc capabilities by a small margin. It must exceed the capabilities of the disc in the talking book program by a substantial margin. It must show superior capability for three to five times the number of copies now produced in the disc program at comparable costs and with equal or greater efficiency. This is particularly pertinent in the case of the time period required to produce periodicals. A very meaningful efficiency would have to be demonstrated in the matter of duplication here.

If I recall correctly the British system utilizes a six to one duplicating ratio; this would mean that an 18-hour book would require 3 hours to duplicate; a 60-hour book would require a 10-hour duplication time. How long would it take this duplicating system, using cassettes, to make 500 copies of a 60-hour book?

PROBLEMS OF STANDARDIZATION IN THE TALKING BOOK PROGRAM

ROELF G. BOITEN
Technische Hogeschool, Delft, Netherlands

INTRODUCTION

For obvious reasons a talking book is of primary importance for blind persons or those with visual impairment. Experience in the Netherlands has shown that their main interest lies in the novel and in light literature for their entertainment value. On the whole there is some danger that talking book users will lose interest in studying braille, or will tend to lose their ability to read it. For serious study in the sciences (and like pursuits), it has been found that results with talking books are far inferior to results obtained using braille books. For study of languages, on the other hand, talking books proved to be of great help, although dictionaries and other reference works in braille must still be consulted. In fact, a combination of talking books and braille texts, used under experienced guidance, has proved to be the best solution for most students. A study conducted in the Netherlands has shown that talking books are of importance not only for the blind, but also for other handicapped persons. Elderly persons, hospitalized or immobilized patients, persons suffering from polio, arthritis, rheumatism, spinal cord injury, and prisoners—all could benefit greatly from the use of talking books, and actually they are very eager to obtain them. The world-wide shortage of nurses makes it virtually impossible to continue the older practice of reading to patients.

In the Netherlands, estimates inferred from the circulation of books in public libraries and the sales of booksellers indicate that about 10 percent of the population reads novels more or less regularly. Of this 10 percent, roughly 5 percent belongs to those categories of persons mentioned above who would be interested in using talking books. In terms of numbers, this means that in the Netherlands, with a total population of nearly 12 million persons, about 50,000 would be regular readers of novels. Ten percent of these, or 5000 readers, belong to that group with impaired vision who read novels regularly in talking book form. This figure may vary for different countries, but it should be noted that the total number of potential users of talking books is some multiple of the number of blind persons.

Although organizations for the blind have pioneered the introduction and use of the talking book program, and certainly were the first to build a library system, it would be unwise not to take into account some of the developments anticipated in the foreseeable future. The problem of standardization, therefore, is very important. At the present stage of development of the art of sound reproduction the most important media are the phonograph record and magnetic tape. The greatest difference between these two media lies in the methods used to solve the problem of duplicating them. A large number of copies is easy and inexpensive in the case of phonograph discs, but small production runs are extremely expensive. In the case of magnetic tape, the opposite situation obtains. By inferring from the data gathered over a period of several years, we can estimate that, in the Netherlands, each year about 1250 new book titles are added to the talking book library, of which about 1000 are novels and the rest technical text materials. About 24 copies would be required on the average, thus requiring a total production of about 30,000 copies a year. Actually, the number of copies needed will vary from book to book. In approximate terms, one can say that out of 1250 titles, 1 copy is required of 340 titles; 10 copies of 200 titles; 20 copies of 300 titles; 50 copies of 400 titles; and 200 copies of 10 titles. It is obvious that in the case of most titles few copies are needed; hence magnetic tape is the obvious choice for talking books.

TAPE RECORDERS: CHARACTERISTICS AND DESIGN

Once this basic decision to use magnetic tape is arrived at, the question of the availability of a suitable tape machine arises. As the amount of capital investment in a talking book library is the major part of its total operating expense, the selection of an appropriate type of machine is of the utmost importance—particularly so in the light of the fact that the useful life of a talking book will be about ten years. In arriving at a decision as to type of machine, the following factors are taken into consideration:

1. The provision of record and reproduce functions, or of playback function only
2. Whether or not a commercially produced machine is satisfactory.

RECORD/REPRODUCE VS. PLAYBACK ONLY

The basic requirement for a machine suited to the user of talking books can be met by a machine provided with playback capability only. Yet in the

Netherlands a substantial proportion of blind persons possess a machine already which has both record and reproduce capabilities. A study of such blind persons indicates that the tape machine is used only in part for reading books, and quite often for the most minor part of its over-all usefulness. A large proportion of blind users of tape machines indicated that the machines are used extensively for correspondence with friends and relatives, both sighted and visually impaired. These users would abstain on no account from using a tape machine in this way.

An appreciable number of users also indicated that they were accustomed to recording certain lecture courses off the air for further study and reference; and to play back these and other programs recorded off the air when the listener was not at home. For professional use, that is, for the use of lawyers, ministers, students, and so on, the need for recording facilities is quite obvious. In short, the majority of visually impaired persons using magnetic tape machines use the record facility for a number of important and serious purposes. A survey of a number of large European manufacturers of magnetic tape recorders has revealed that some of them had developed prototypes of equipment having playback facilities only. An analysis of the marketing possibilities of these machines has made it clear, however, that the price reduction of such a machine would amount to no more than 30 percent less than that of a machine having both record and reproduce ability. This small a difference does not justify, therefore, a separate production run of such instruments—less attractive to the public in any case—so that in the near future at least no major manufacturer is considering commercial production of a tape reproducer. Most of the current designs have taken the precaution of arranging the operating knobs and controls to eliminate or at least greatly reduce the possibility of unintended erasure. Librarians in charge of the talking book libraries have confirmed the fact that damage to the talking books through erasure is negligible as compared to other kinds of damage to the tape.

In summary, it was concluded that the talking book user should be provided with a tape machine which can both record and reproduce magnetic tapes.

STANDARD COMMERCIAL MACHINES VS. SPECIALLY ADAPTED DESIGNS

For the machine itself, the design utilized can take any one of three basic forms. The first is a normal, commercially available tape recorder/reproducer. The second is a special design adapted to the needs of the visually impaired without regard to commercial design. The third is a modification suited to the needs of blind users but using tape and tape reels compatible with standard commercial machines.

The second alternative can only be justified as a last resort. In today's economy, low cost can be achieved only with the use of mass production techniques. The manufacture of special items in small quantities always ends in the result of less value to the user for each dollar paid than for the mass produced item. Furthermore the service and maintenance problem must be taken into consideration; major manufacturers already have established local service centers, or provide local dealers with service facilities and spare parts. In the Netherlands a service contract is available to any purchaser of a tape machine for a small fixed fee; for the blind, an additional provision provides for a twice-yearly service call for a routine maintenance check, while emergency service is available in the event of machine failure. Incidentally, in the Netherlands, a standard commercial machine is used with motion picture type reels and four track tape of one-quarter inch width.

A number of other aspects of tape machine use came to light in the study mentioned above. The most important of these are summarized below:

1. The weight of the tape machine should be as low as possible, and the lid or cover should be removed or replaced easily by visually impaired persons.
2. Threading of the tape should be easy; the machine should stop automatically if the tape breaks; removal of a split tape and replacement of a spliced tape should be possible without dismantling any part of the apparatus.
3. Reels should be placed in a cassette-like container, either lying adjacent to one another in the same place or concentrically, one above the other; the entire tape path should be contained within the cassette, including a brake which is deactivated when the container is placed on the tape deck; it should be possible to remove the cassette at any time, whereupon the brake should act immediately. This last provision allows the user to interrupt the talking book, use his tape machine for some other purpose, and to continue his reading afterwards without interruption at the point where he stopped.
4. The design should incorporate automatic volume control.
5. Input sources should be provided each with a different type of connector to avoid accidental misuse.

6. A provision should be made for headphone use with automatic loudspeaker cutoff to avoid disturbing other persons.
7. Fuses should be located for easy replacement in a straightforward manner.
8. Controls should be placed in such an arrangement as will facilitate handling the tape and prevent errors; they should include braille dials and markings where necessary or useful.

Although some commercially available tape recorders are provided with some of these features, there is none which includes them all. For those using talking books professionally, there are other desirable features, such as the ability to index stored information, which might be included. The need for such a facility is obvious in the case of a lawyer using talking law books, but it is useful also for the user reading scientific material for reference. The need is less obvious in the case wherein, as in the Netherlands, a book like the Bible is recorded in its entirety. Normal use of this talking book without a suitable indexing system is virtually impossible.

In sum it may be said that there is no commercially available tape machine in the market fulfilling all the wishes of the blind talking book user. A special production run is worthwhile, however, only if the design can be adapted to other uses and the production run is thus not too small. Any special recorder based on the above considerations must be compatible with existing recorders so that it does not obsolete existing equipment and materials and permits its use for purposes other than simply reading talking books.

TAPES, RECORDING SPEEDS, AND DIMENSIONS

The standard tape width for most common entertainment type purposes is one-quarter inch, plus or minus 0.002 inch. No reason has been found to deviate much from this standard width, especially in view of our requirement of compatability with existing equipment.

Standard tape speeds are summarized for various applications in Table 1.

There seems to be no standardization on speed in talking book production.

Commercial tape machines are available with either two track or four track heads, using one-quarter inch tape. Of 60 tape machines of European manufacturers, surveyed for this use, 59 percent use two tracks, and 41 percent use four tracks; the first group uses what is called the "half track"

TABLE 1

RECORDING SPEED, SPEED TOLERANCE, AND FREQUENCY IN STANDARD APPLICATIONS

Speed		*Speed Tolerance*	*Frequency Range*
in./sec	*cm/sec*	*Percent*	*cps*
30.0	76.2	0.2	40-15,000
15.0	38.1	0.3	40-15,000
$7\frac{1}{2}$	19.05	0.8	50-10,000
$3\frac{3}{4}$	9.54	2.0	100- 6,000
$1\frac{7}{8}$	4.77	?	?
$\frac{15}{16}$	2.39	?	?
4.0	10.16	?	?
2.0	5.08	?	?

system, while the second group uses what is called the "quarter track" system.

Recording speeds utilized in present commercial machines intended for nonprofessional use are listed in Table 2; the percentages represent the proportion of the same group of 60 tape machines using the speeds indicated.

TABLE 2

RECORDING/PLAYBACK SPEEDS AVAILABLE IN A SAMPLE OF COMMERCIALLY AVAILABLE MACHINES

	Tape Speed	*Percent*
Single Speed (in./sec)	$3\frac{3}{4}$	23
	$1\frac{7}{8}$	2
Two Speeds (in./sec)	$7\frac{1}{2}$—$3\frac{3}{4}$	23
	$3\frac{3}{4}$—$1\frac{7}{8}$	21
Three Speeds (in./sec)	$7\frac{1}{2}$—$3\frac{3}{4}$—$1\frac{7}{8}$	27
	$3\frac{3}{4}$—$1\frac{7}{8}$—$\frac{15}{16}$	4

From Table 2 one can see that half of the sample of commercial machines provide for a tape speed of $7\frac{1}{2}$ in./sec; 98 percent for a speed of $3\frac{3}{4}$ in./sec; 27 percent for a speed of $1\frac{7}{8}$ in./sec; and 4 percent for a speed of $\frac{15}{16}$ in./sec. The preferred speed for standardization would therefore seem to be $3\frac{3}{4}$ in./sec (9.54 cm/sec), and this is the tape speed adopted for talking books in the Netherlands. The frequency range for this speed should then be from 100 to 6000 cps, and this has been found to be the case with nearly every machine tested. Many manufacturers claim a wider frequency response, but this would hold only in the special case that a tape was played back on the machine on which it was recorded. Talking books are apt to be played on a wide variety of machines other than that on which they were recorded; moreover, the heads on these instruments will have varying amounts of wear of gaps, and varying degrees of error in azimuth alignment.

The size and quality of loudspeakers included in such equipment, depending on the space available for them, makes the use of a frequency range greater than that noted above of questionable value. Experience has shown that for a frequency range of 100 to 6000 cps the tape itself should retain the frequencies from 100 cps to 10 kc/sec. All the frequencies below the range of 250 to 300 cps are of minor importance to listening quality in talking book applications.

At the moment a tape speed of 3¾ in./sec seems to be the best compromise among the different factors already mentioned, although recent improvements in tape coating techniques and record/reproduce heads make it likely that within the next five years the same quality standard will be attainable at a tape speed of only 1⅞ in./sec.

A choice between half track and quarter track machines is harder to make. Due to the smaller width of each track in the four track machines the signal/noise ratio is, in current practice, definitely worse than in the typical two track machine. In addition, as the outside tracks are near the boundary of the maximum tape wear, unequal strain over the width of the tape deteriorates the sound quality of these outer tracks very rapidly. What might be thought to be a saving in tape costs because of the doubled information storage density turns out to be somewhat illusory, as a tape of much better quality and unfortunately higher cost must be employed to get the same, or at least comparable, results as with the two track system. Narrow tracks and narrow track spacing require a multitrack system with a greater tape width. The greatest advantage of the quarter track system remains in the saving of storage space and mailing costs over a comparable playing time on half track tape systems.

Experiments with the two systems have shown that a half track tape can be reproduced on a machine fitted with a quarter track playback head, with acceptable quality, using only the inner track gap. It is impossible, on the other hand, to reproduce even two tracks of a four track tape on a half track machine. Standardization is therefore suggested on a half track, one-quarter inch tape and a playing speed of 3¾ in./sec, with provision for change-over to the quarter track system when the tape art and the equipment permit, and even for an alternate speed of 1⅞ in./sec. Thus, the proposed and suggested standard tape machine for the talking book should be of the two speed type (3¾ and 1⅞ in./sec) with a two track head, the latter allowing of easy replacement with a four track head if desired at a later date.

The useful life of a tape recorder/reproducer can be estimated at about 2000 hours, and the useful life of the record and playback heads at from 300 to perhaps 600 hours. Normal replacement could take place during the twice-yearly service and maintenance calls made (as in the contract arrangements made in the Netherlands). With this arrangement, the library can change gradually from half track to quarter track tapes as the alteration in recorders takes place. This policy is already in effect for the talking book libraries in the Netherlands.

Nearly all commercially available tape recorders use motion picture type reels, with the main exception the special class of dictation machines. In the above-mentioned survey of European machines, it was found that all of them could accommodate reels with a diameter of 3.2 inches (80 mm); 90 percent could accommodate reels of 5.2 inches (130 mm) or less; 80 percent reels of 6 inches (150 mm) or less; 64 percent reels of 7.2 inches (180 mm) or less; 9 percent reels of 8.5 inches (210 mm) or less; and 4 percent reels of 10 inches (250 mm) or less. Since most users want a compact and lightweight machine, and since its dimensions are often in proportion to the maximum diameter of the tape reel, after some experimentation a compromise size of 6 inches (150 mm) was selected. In practice the results are good: larger reels give rise to difficulties with the carrying case in transport, usually done by post. For these 6-inch reels a heavy gauge re-usable cardboard box has given excellent service. Depending on the thickness of the tape material, 1200 to 1500 feet (360 to 540 meters) can be accommodated per reel, giving a playing time of two to three hours with 3¾ in./sec tape speed and a two track machine. Thus the contents of the normally encountered novel can be placed on four to seven reels. With a quarter track machine and a playing speed of 1⅞ in./sec the contents of the same novel could be recorded onto one or two reels.

Tape recordings can be utilized of course for periodicals and for novels. In the Netherlands there are five talking periodicals already in existence, publications among them with a weekly circulation of nearly 1000 copies. The contents of each issue can be placed on one 6-inch reel, which the subscriber receives on Saturday morning, even before he has posted the previous week's issue for re-use. Our experience has shown the 6-inch reel to be ideally suited to this program. The copying of these periodicals requires a vast and well-organized tape copying setup which is active, however, only a few days a week. Economic pressures dictate that the tape center should be used for making talking books during the remainder of the week. It is only logical therefore to standardize on the same size reel for both talking books and talking magazines.

Some economy can be realized by making the cassettes in which the tape is used of the "bookcase" variety, for these are cheaper to ship by post and are less liable to break. The user can put the reels in the cassette or use them just as they are, as he likes.

INDEXING

One problem yet to be solved is that of providing a suitable and yet not too expensive means of locating desired passages within a talking book. The problem has been studied intensively, and a number of possibilities have been explored. Three of these will be described; an assessment of the advantages and disadvantages of each method will be outlined.

Replacement of the Tape Counter Wheel with a Brailled Counter Wheel

In this system each reel must be accompanied by a register in braille giving the contents as a function of the counter reading. One manufacturer in the Netherlands has undertaken the design of such a counter, and the 3000 to 4000 tape machines already in use by the blind will be provided with this new counter at a very modest cost.

There are disadvantages with this system, however, and among them we may note the following:

1. There will always be some slipping between the tape transport and the counter wheel, so that after some period of use there will be deviations between the counter and the tape registration.
2. Counter wheels can only be read while at rest, which means frequent stopping of the tape and all the extra wear on tape and transport attendant thereto, plus loss of time in searching.
3. During the search operation both hands of the user are fully occupied.
4. In the search operation the tape must be started at the beginning of the recording and the counter must be reset to zero each time; this is a time consuming requirement, particularly when using a number of reference books.

Using the Inner Tracks of Quarter Track Tape for the Talking Book and the Outer Tracks for Pulsed Code Information on Page Numbers

With this system a pulse counter with braille wheel markings can present the page number. The counter should be capable of counting forward and backward. With a second pre-set counter, it is possible to make the machine stop when the desired page has been reached.

Among the disadvantages of this system are the following:

1. It is rather expensive, and it is rather bulky.
2. The system is not compatible with existing recorders, and with existing talking books in the libraries.
3. Counting errors cannot be checked in progress, and the counter must be reset to zero, as with the first system.

Working Back and Forth with the Fast Forward/Fast Reverse Facility

If the difference between tape drive speed and Fast Forward/Fast Reverse is in a ratio of twenty or thirty to one and is reasonably constant, it is possible to employ vocal (i.e., speech) codes on the tape itself. For this purpose the lower frequency range—up to about 200 cps—is pre-empted for indexing purposes. A high pass filter is employed in the amplifier which blocks all frequencies below 200 cps. Such a filter is both inexpensive and easy to make. Furthermore, due to the acoustical properties of the commonly employed loudspeaker/enclosure system in the usual tape recorder, it is nearly impossible to detect the difference in sound accuracy by ear.

While the tape is fed through the machine at high speed, using a separately driven capstan, all of the frequencies recorded on the tape are multiplied by the same factor characterizing the change in tape speed. The low range which lies below 200 cps will then rise into the range of maximum intelligibility. Thus it is possible to record vocal data regarding the contents of a book directly onto the tape which is then audible only at high tape travel speeds. To reduce playback head wear the tape can be lifted clear of the gap with not too much loss in voice quality.

It has proved impossible, unfortunately, to change the tape transport mechanism of existing tape machines to this system at a reasonable price. The system can only be used with specially constructed tape machines. The system is compatible, however, with existing recorders, in which only a filter to cut out the lower frequency range need be inserted. Equipment with which to index the master tape from which copies are made is currently under development and does not appear difficult to realize in actuality. For the time being, this system appears to be the best compromise between desire and possibility in the matter of tape indexing. This judgment is based on the feasibility of incorporation of the required features in the transport mechanism of tape machines specially constructed for the use of the blind.

CONCLUSION

Its varied features make magnetic tape an attractive medium for talking books. These features make the talking book attractive to many groups of the handicapped besides the visually impaired. Numerically, handicapped persons outnumber the visually impaired by perhaps ten to one. It would seem that talking books are assured of a good future and will, within a very short time, become available on a much more expanded scale than they are today. It will be necessary, therefore, to take into account these future growth possibilities with a carefully considered program of standardization to avoid the shunting off of the interests of the visually impaired reader with little or no access to other sources of talking books aside from the agencies for the blind.

The tape recorder/reproducer is still a relatively new device and most certainly further technical progress will extend its attractiveness and its potentialities in this application. However difficult it may prove to be, this as yet unknown rate of development should be reckoned within any program of standardization. On the other hand, a useful set of recommendations may help influence commercial development, to the mutual benefit of manufacturers and talking book users.

Because of the already large investment in tape machines, any suggestion for change should be based on evolutionary development using compatible materials and devices. The proposed tape machine for talking books should differ in its essential elements only little from existing designs of commercial tape machines. Our basic recommendations, derived from the discussion above, were based on careful inquiry in the field and on a few years of practical experience with the tape talking book system. They are as follows:

Tape

1. Normal tape of one-quarter inch (6.25 mm) width is preferred.
2. For the immediate future a two track system with $3\frac{3}{4}$ in./sec (9.5 cm/sec) reproducing speed is recommended; future developments may

make possible the achievement of equal quality with a four track system and/or a lower reproducing speed of $1\frac{7}{8}$ in./sec (4.75 cm/sec).

3. Motion picture type reels with a diameter of 6 inches (150 mm) should be used.
4. A book type of cassette in which the user may insert two reels should be available; it would incorporate a built-in brake which operates whenever the cassette is lifted from the tape machine. The cassette would not normally be used for storage or shipment of the reels.

Tape Recorder/Reproducer

1. Facilities should be provided for both recording and reproduction of magnetic tape.
2. The machine should be both compact and lightweight, and accommodate two 6-inch reels or a cassette loaded with two 6-inch reels.
3. Automatic volume control or an audible warning system should be incorporated to prevent both under- and over-modulation.
4. Input and output plugs should differ tactually for each source and load.
5. Knobs and levers should be arranged logically and should be interlocked to prevent errors in operation; braille markings should be used wherever needed.
6. Two speeds should be provided: $3\frac{3}{4}$ in./sec (9.5 cm/sec) and $1\frac{7}{8}$ in./sec (4.75 cm/sec).
7. Recording and playback tape heads should be of the two track variety but easily interchanged with four track types.
8. For indexing purposes a Fast Forward/Fast Reverse facility should be provided with a 20/1 speed ratio; the amplifier should be provided with a high pass filter blocking frequencies below 200 cps.
9. A headphone jack should be provided which automatically cuts out the loudspeaker when the headphone plug is inserted into it.
10. Design and construction of the machine should be so arranged that maintenance and repair service is possible at the user's local radio repair shop.

SUMMARY—PANEL III:
SOUND RECORDING AND REPRODUCTION

ROELF G. BOITEN
Technische Hogeschool, Delft, Netherlands

The most important media for talking books and talking magazines are gramophone records or discs and magnetic tapes. The manufacture of discs is a fairly straightforward process in which there is a characteristic decrease in price per disc as the number of disc copies increases. Disc talking books are available now only in the English-speaking countries (England, the Commonwealth countries, and the United States), in France, and in Austria. For countries with a relatively small number of talking book listeners the price of the disc talking book manufacture would be too high. In the case of magnetic tape, the difficulties increase when the number of copies is large. For small runs of copies, however, it is an excellent medium and for this reason it is near to universal acceptance among the European countries. At the moment there exists nothing comparable to a printing press for tapes; therefore each copy must be recorded individually. The future development of talking books on tape could be hampered seriously if no better reproduction techniques become available, as pointed out by the United States representatives.

Encouraging and informative experience with talking books on magnetic tape over a period of more than five years or so has led to the almost unanimous opinion among the participants that the future of the talking book lies in the use of tape—in spite of the fact that this technique is relatively new and all kinds of technical improvements are to be expected.

At the moment the price of a talking book on discs is lower than on tape, although the actual price difference between discs and tapes depends on the cost of raw materials, reproduction equipment, and the number of copies required. It may be expected, however, that due to the rising popularity of magnetic tape recorder/reproducers, costs will decline in the near future. Technically speaking, the user needs only a magnetic tape reproducer for reading the talking book on tape.

All European countries, England excepted, who have had experience with tape talking books, hold the opinion that the apparatus provided to the reader should be able to record and to reproduce sound. The British have not considered a recording facility necessary and other participants, through lack of sufficient experience, decline to express a pertinent opinion.

The view was also expressed that the handling of the recorder should be as easy as possible; as an expression of this view, the desire for a cassette system was widely stressed.

There was no consensus among the participants regarding the question of special adaptation of the machine to the needs of the blind versus the minor modification of commercially available equipment to suit their needs. Great Britain has developed a system using a cassette with two stacked reels of one-half inch tape and 18 tracks which gives a total possible reproduction time of 21 hours. For this system, a special reproducer was developed and is now in production and distribution together with copying facilities. The system has been accepted in the Commonwealth, in Spain, and in Argentina.

In the United States prototypes have been built of two machines using cassettes and auxiliary equipment. In the near future a number of these instruments will be placed on a trial or field distribution test basis.

The Continental European countries all use commercial one-quarter inch (6.25 mm) tape on motion picture type reels. Selection of a special system implies that all duplicating and maintenance of apparatus has to be undertaken by the organizations who distribute the reproducers, whereas by adhering to the commercially and internationally accepted standards, the duplication and maintenance functions can eventually be transferred to specialized firms, thus requiring a smaller capital investment by those responsible for programs of service to blind readers.

It was impossible to come to a common agreement on this question, although it became clear that countries with already established talking book facilities will be slow to consider the British system.

Emphasis was laid on systems that are compatible with regard to talking books so that exchange programs can be undertaken with other countries on a worldwide scale.

It would therefore seem advisable, in summary, to establish an international panel in this area with the aim of advocating and studying the possibilities involved, and to direct future research so as to achieve the eventual goal of compatibility in the systems in use all over the world.

Panel IV—Adapted and Special Purpose Devices

SECTION I—*Education: Reading and Writing*
CHAIRMAN: Edward J. Waterhouse
Perkins School for the Blind,
Watertown, Massachusetts

SECTION II—*Vocational Aids*
CHAIRMAN: Arthur L. Voorhees
American Foundation for the Blind,
New York, New York

SECTION III—*Radio and Electronic Aids*
CHAIRMAN: Robert W. Gunderson
New York Institute for the
Education of the Blind,
Bronx, New York

INTRODUCTION

The following pages contain the papers presented during the meetings of the Panel on adapted and special purpose devices. The Panel was chaired by Mr. John Colligan, the executive director of the Royal National Institute for the Blind in London, England.

Though the scope and range of the devices reported upon is very wide, our intention in this Panel was to concentrate on those devices which can be said to materially assist the visually impaired to learn, to work, and to play in this everyday world. The emphasis was thus primarily practical, although a few experimental devices are included because of their special relevancy. The extension of experimental objectives in development of such devices beyond the more practical requirements of the blind user is covered in much greater detail in the first two volumes of these *Proceedings,* in the Panels devoted to man-machine systems and living systems.

In our desire to make this discussion of a wide range of such devices (and a few techniques) as useful to the reader as possible, we have expended a good deal of additional effort in compiling a catalogue listing every device past and present, useful or no, known to us at the present time. This catalog will be found in Volume IV of these *Proceedings;* it is entitled the Catalog Appendix. Each of the devices is described within a uniform format, which will facilitate rapid scanning in a search for particular devices or classes of devices; the eye is assisted by the dictionary-type headings at the top left and top right of each double page.

A group of users of great importance to whom we have unfortunately paid scant enough attention in these papers is that of the so-called emergent countries. Unless one has actually surveyed the needs of workers attempting to alleviate the restrictions imposed on the visually impaired in many regions of the world outside the common orbit of the technically advanced nations, it would be difficult to understand fully their simplest needs—for really inexpensive writing slates, or canes, or many other devices. In the advanced nations, we are concerned with quality and we do not blanch at complexity; but the needs of many persons over the world for truly inexpensive solutions to the most elementary problems of the blind and visually impaired are still largely unmet. It would not be too much to hope that the readers of this volume will help us to remedy this situation at the earliest opportunity.

The collection of information in these pages represents, we think, perhaps 90 to 95 percent of all that is known of the adapted and special purpose devices over the world. As any researcher can testify, however, the collection of that major proportion of the data, although difficult in itself, still represents only about half the over-all effort needed to achieve completeness. The additional 5 to 10 percent of data needed to complete this discussion and the catalogue listings which follow will occupy us for some time; some data must come from you, the readers, to us.

When so much has been accomplished—and most of all by the blind themselves, who have taught the sighted many new and better ways of approaching old problems—we need not end this note with dour negativism. A simple reading of the material in the following sections will encourage the belief that an enormous amount has been accomplished in an effort to meet the everyday needs of the blind person and to increase his comfort and his efficiency. We should also be encouraged by the occasional flashes which can be seen here of the fruitful interplay between the more experimental and research-oriented work reported on in the first two volumes of these *Proceedings,* and pragmatic or empirical solutions to practical problems.

The brilliance of this achievement in alleviating the restrictions imposed by blindness as shown in the following pages should encourage us and make the following discussions as fascinating to the reader as they seemed to be to the participants themselves.

L. L. CLARK

SECTION I

EDUCATION: READING AND WRITING

CHAIRMAN: EDWARD J. WATERHOUSE
Perkins School for the Blind, Watertown, Massachusetts

SMALL SCALE BRAILLE PRODUCTION AND DUPLICATING SYSTEMS

VIRGIL E. ZICKEL
American Printing House for the Blind, Louisville, Kentucky

SMALL SCALE BRAILLE PRODUCTION AND DUPLICATING SYSTEMS

To interpret this title in the strictest sense would probably limit this discussion to only those processes that have been found most practical for the production of some small number of copies of braille, such as 20 or even less. However, since it is one of the purposes of the Congress to make a complete survey of all technical development, either proposed or completed, designed for the alleviation of the effects of blindness, it seems appropriate that all known methods for producing multiple copies of braille be reviewed in this section. Since the two papers to follow will be concerned with only long run processes, this paper will attempt to cover all systems designed for the production of multiple copies with the exception of the solid dot and interpointed embossed double plate systems.

Much of the data in this paper has been reported or published previously. Full use has been made of this information and suitable credit has been given to those sources and their authors.

ESPINASSE DUPLICATOR

The Espinasse Duplicator is similar in appearance to and operates like a conventional inkprint proof press. The complete unit consists of the duplicator, a chase that carries the braille characters for printing, and a font or reservoir similar to the chase where the embossing pins are stored when not in use.

The press proper consists of a flat base fitted with a gear rack along each edge, a roller fitted with spur gears that mesh with the rack to provide exact registry between the roller and base surfaces. The roller has craters or depressions corresponding to the braille cells throughout its length and its circumference is an exact multiple of standard braille line spacing.

The chase consists of two sheets of metal, approximately one-eighth inch thick, fastened together with a rubber sheet between. The chase is drilled with all of the braille cells possible within the size limits of the machine.

A chase set up for printing would have rounded steel pins extended approximately one-sixteenth inch above the surface for each braille dot desired. This arrangement permits the pins to enter far enough into the depressions in the roller necessary to produce good braille dots. In operation, a sheet of paper is placed over the pins and the roller moved from one end of the duplicator to the other. The pins then force the paper into the depressions in the roller embossing the paper.

The font or feeder block is similar to the chase, differing only in thickness. It is actually equal to the full length of the pin.

The chase is fitted with dowel pins to locate it properly on the duplicator. These locating pins also afford exact registry between the font and the chase so that the braille pins can be readily transferred from the font to the chase or vice versa.

To set up a braille page with this system, the font is placed over the chase and a stylus used to push the desired pins from the font to the chase. When the required number of pins have been transferred, the chase is placed on the press with the pins projecting above. When the required number of copies have been printed, the chase and the font are again registered and the stylus used to return the pins to their original position.

Since the pins and craters form a male and female die, the braille produced with the Espinasse system is good, being very nearly equal in quality to that produced on a braillewriter. When once set up, an almost unlimited number of copies can be made and the cost per sheet is very small. However, the time required in setting up the page and transferring the pins when the job is completed is considerable.

The exact cost of the duplicator is not available; however, the precision required in its manufacture: the accurate registry of the chase with the roller, the accurate registry of platen and font, the precise location and depth of the impression roller craters, and the vast number of accurate pins required, suggest that the system would cost several thousand dollars.

It is, of course, possible to have additional chases so that a setup could be stored for future use, but this seems impractical due to the large investment. Of course, the braille is one-sided only and since the size of the machine permits only single page operation, only single sheet bindery operations can be used.

THE MULTIGRAPH BRAILLE DUPLICATOR MANUFACTURED BY THE ADDRESSOGRAPH-MULTIGRAPH CORPORATION, CLEVELAND, OHIO

This machine is available in three sheet sizes: 8 inches by 8¾ inches; 11 inches by 16 inches; 13 inches by 17 inches. The prices range from $345 for the smallest size to $1375 for the largest one. The machine is normally furnished for hand operation, but it should be possible to fit it up with a motor drive with a minimum of time and cost.

In operation, paper is fed between two drums, one of which carries the braille characters, while the other is covered with a rubber blanket. This operation is very much like that of an offset press.

The drum is a conventional Multigraph drum with "T" slots for locating and holding the type in place. Each braille character is made on a standard slug with a key which fits in the "T" slot, locating the characters with correct character and line spacing.

The 64 braille slugs are stored much in the manner of a conventional type drawer. However, slugs containing most two-cell braille contractions are also available. The cost of type is $1.25 for 25 pieces of each character, or an assortment of 1600 pieces can be purchased for $75. The quality of braille produced with the duplicator is very good, but it permits only one-sided printing.

The time required for embossing is relatively small, and the cost per page is determined largely by the time spent setting and distributing the type. This is roughly equivalent to normal inkprint composition time. The machine was designed to emboss Hammermill braille paper, but any other good braille paper can be used. With the machine sizes available, only single sheets of 11 inches by 11½ inches can be embossed; therefore, single sheet bindery processes must be used except in smaller sizes.

Since the type and segments are expensive, setups are not normally stored for future use, but pied at the end of each run.

THE SYSTEMATICS INTERCOUPLER

This device was designed and built by the Systematics Division of General Instruments. The prototype was demonstrated at the Jewish Braille Institute of America on April 4, 1960. It was also the subject of a feasibility study made by Robert Wolfson of the Adelphi Research Center in 1961.

The Intercoupler consists of four units: A modified Perkins Brailler, tape punch, tape reader, and a power supply. The braillewriter has been modified by the addition of contacts for the control of the tape punch, solenoids to operate the keys, and a motor drive to provide power carriage return. These units are connected through suitable switches so that an operator making a braille copy on the writer automatically records the information on punched paper tape. Additional copies are made by feeding the tape through the tape reader which in turn controls the braillewriter. It is reasonable to assume that additional braillewriters could be controlled by the tape read unit, thereby providing larger volume production if desired.

Since the embossing is done by a Perkins Brailler, the braille produced by this unit should be of the best quality although, of course, only one-side braille is possible. The tapes could be stored and used for additional copies at a later time.

Wolfson reported that a greater degree of dependability is required than exists in the prototype unit. This seems especially important since it would probably be used by volunteer groups where maintenance men might not be readily available.

For volunteer use, portability would also be a definite advantage. It appears reasonable that the machine could be redesigned, permitting the entire unit to be housed or contained in the equivalent of two small suitcases. If such further development is undertaken, the circuity should be changed so that the machine would use the punched tape coding approved at the Braille Conference held at MIT in March, 1961. The tapes then would be compatible with other tape controlled systems, either now in operation or contemplated for the future.

Although it is easy to proofread the original braille copy and make simple corrections as written, later corrections on the tape are impractical since this means finding and cutting out the error and splicing in a correct section. Further study and development are necessary in this area. It has been estimated that the device could be produced in limited quantities for approximately $2000 each.

Several other systems using punched paper tape as the storage or intermediate step in the production of duplicate copies of braille have been proposed or developed.

John Haynes, formerly with Stanford Research Institute, Menlo Park, California has used the Flexowriter to originate the punched tape that is later used to control a modified brailler in much the same fashion as the Systematics system.

Richard Woodcock, Department of Special Education, Colorado State College, developed a similar system with a choice of either a braillewriter keyboard or an alphanumeric keyboard as the input, and using an electrically controlled braillewriter as the output. Punched tape is used for control and storage.

The American Printing House (APH) has a three-unit system consisting of a braillewriter–tape punch unit to provide correct format and to originate a tape, a tape reader–braillewriter–tape punch unit for verifying, and a tape reader–plate embossing machine as the output. However, a braillewriter fitted with solenoids and power carriage return could be used as the output.

THE THERMOFORM 55 VACUUM FORMING MACHINE

This machine is manufactured and distributed by American Thermoform. It was designed for the reproduction of braille and other three-dimensional material by the vacuum forming method. It is compact, being approximately 14 inches by 18 inches by 14 inches high. It operates on standard 115 v household current, and according to the manufacturer an operator can produce 150 copies or more in an hour if desired.

Braille copies are produced by placing the master on the platen of the machine, raised impression side up. A sheet of plastic film is placed over the original and locked in place by closing the clamping frame. The heating oven is pulled into position over the frame and in approximately two seconds the vacuum is applied. The heating cycle and vacuum control are both automatic. The price quoted on the machine is $450. This method is probably the most widely used method for producing duplicate copies of braille.

The manufacturer also supplies a green translucent matte finished plastic sheet which seems to be very well accepted. The cost in lots of 2000 sheets is less than four cents each. This system affords good one-side duplicate copies of braille. Binding is accomplished by cementing the sheets together and into the cover. These sheets can also be punched and ring bound.

At least two other machines have been developed to produce duplicate copies of braille in plastic by vacuum forming. However, these have not been as highly developed and widely accepted as the Thermoform machine.

The Vacuum Formed Plate System developed at APH utilizes the vacuum forming principle to provide plastic plates which are then used to make duplicate paper copies. The plates are made by vacuum forming successively two sheets of plastic over the braille copy; the plates are then registered and stapled together. A vast amount of pressure is needed to produce paper copies with these plates, but an extra heavy duty cutting and creasing press works nicely.

Sponge rubber is used for the underlay on the female side and gum rubber for the male side of the plates. Some loss of height (approximately 10 percent) is usual with this process. However, when the original is of good quality, the duplicate copies have firm unbroken dots providing braille which is readily accepted. Moistened Hammermill braille or Sorg braille paper is used for the copies.

Since two sheets of plastic are needed to make a set of plates, this process finds its greatest usefulness for five or more copies. As in most duplicating processes, only one-sided braille is possible, but since two-page signatures are produced, any of the conventional binding processes can be used.

UFORMITE PROCESS

This process was developed at the Philadelphia Chapter of the Volunteer Service for the Blind under the direction of Mrs. J. M. Beck, with the cooperation of the Rohm & Haas Company. It is a refinement of the Guerin process which was developed in France and also used for a number of years at the Philadelphia agency.

In the Guerin process, an embossed master is first coated with thin shellac. The sheet is then placed braille side down on a smooth surface (such as a square of broadloom carpet) and a frame having the same length and width as the paper and one-eighth inch thick, is placed on the back side of the paper. The frame is then filled with a special plaster and the surface leveled so that the finished plate will be parallel or of equal thickness. To make copies with this plate, a rubber blanket was used to form the female side of the page and a wringer press used to supply the impression.

In the Uformite process the master braille sheet is also coated on the embossed side with shellac. However, the reverse side is coated with a thin film of urea-formaldehyde resin instead of the relatively thick plaster of the Guerin process (24 inches by 36 inches, 100-pound Springhill Index has been found to make the best masters). The resin is prepared in small quantities and carefully worked into the dots with the excess being trowelled off so that only a thin even coating remains. The proportion of catalyst to resin is such that it will cure at room temperature in approximately 30 minutes. However, the masters were usually allowed to cure overnight to ensure that the plastic had set completely and maximum strength obtained.

To produce duplicate copies, the master is fastened to one platen of a flat-bed press and a rubber blanket is fastened to the other side to serve as the female section, while suitable gauges are provided to register the sheets. The setup then is much the same as that used for inkprint job press work. A wringer press has been used but the flat-bed press makes much better braille.

The quality of braille obtained is acceptable, although there is probably some loss of dot height. It is, of course, a one-sided process and single sheets are usually produced. It seems reasonable that a larger press could be used so that two sheet signatures could be embossed with each stroke of the press, making for a more rugged binding. It is possible to make a vast number of copies with this process.

Plates made by the Uformite process have been used to print several hundred copies and they could, of course, be stored for future use if desired.

A few years ago, the Cycleweld Cement Division of the Chrysler Corporation developed a plastic, probably one of the epoxy group, intended to overcome some of the disadvantages of the urea-formaldehyde resin material. Because of the many variables found in each of these processes and the accuracy of measurement, the precise control of temperature and humidity, and the high order of manual skills required, it has been replaced by the embossed metal plate system.

There are other methods, materials, and systems for producing a limited quantity of braille. Some of these are well-known, such as the Gestetner process which operates on the principle of the mimeograph, the Royal National Institute for the Blind Crab writer for producing thin aluminum plates, and the APH adapted automatic center punch for embossing metal plates. There are probably others that have not come to our attention. However, it is felt that the above descriptions fulfill the intent of the Congress in giving the history of the most popular ideas for producing a limited number of copies in braille.

SOLID DOT BRAILLE PRINTING

CEDRIC W. GARLAND
Royal National Institute for the Blind, London, England

The system of embossed writing invented by Louis Braille has been the universal key to literature and music for nearly one hundred years. During this period there has been no substantial alteration in the method by which it has been printed.

One great disadvantage of this method is its bulk and this is illustrated by the fact that the most widely read book of all, the Holy Bible, consists in its embossed form of no less than seventy-four 80-page volumes of interpoint braille, and the average novel requires three volumes. Any system, therefore, that substantially reduces the physical dimensions of books for the blind is vitally important.

Traditionally, braille has been produced on stout paper by distorting the fibers to form hollow dots, and apart from bulk there is the question of its durability or its ability to withstand repeated reading and handling in transit.

The quest for a more permanent braille by the deposition of dots on paper goes back at least 40 years, but it has been only recently that technical advances, particularly in the field of plastics, have made possible the development of a practical and economic process.

After many years of trial and error the Royal National Institute for the Blind (RNIB) has perfected a method of depositing and heat-sealing solid dots of plastic onto the surface of a thin, strong paper, and based on this method a complete processing plant has been designed. The thickness of braille publications so produced is reduced by approximately 45 percent and, in addition, the dots are uncrushable and do not deteriorate with use. The system, although more costly to install than an embossing plant of similar output, is quicker and less expensive to operate.

The process which the RNIB has developed results from experiments with an extensive range of plastics and papers, and only two plastics proved to be suitable in control of dot dimensions. The first, based on urea-formaldehyde (UF) initially produced such promising results that an experimental machine was built. Samples of the braille were widely circulated for examination by the blind and the comments received were so favorable (with a 77 percent approval) that it was decided to proceed in terms of a production machine. Unfortunately, this material and its method of application subsequently proved to be unsuitable for continuous high speed processing due to many factors, including the short working life of UF at ambient conditions of temperature and humidity. Therefore, a completely new approach had to be worked out.

After consultations with specialists in the plastics industry and further preliminary tests it was decided to investigate the use of polyvinyl chloride (PVC) paste. This material is widely used in industry, is readily available at low cost, and can be substantially modified to suit specific applications. After extensive experiments with many grades, a suitable material was developed.

The particular PVC paste now in use is a specially formulated thixotropic grade composed of polymer, plasticizer, and a balanced filler content to meet the need of both the process and the end product as follows:

1. It must be nontoxic as a contact material.
2. Dot shape must be maintained both in the paste form prior to gelling and also during gelling.
3. Gelling must be effected below the flash point of the paper.
4. The braille dots must be of a suitable hardness and possess a good quality of adhesion to the paper.
5. The working life of the paste must be of a length to permit bulk storage for a reasonable period.
6. These requirements have now been met.

Considerable research has also been directed to produce a thin, economical paper which will withstand the tension and heat to which it is exposed on the machine and at the same time have a surface texture which will acept dot adhesion and still be substantial enough to prevent the dots on one side being detected through the paper. The material selected is an unsized kraft paper of 28-pound substance, .004 inch to .005 inch thick, produced to a close specification of fiber length, tensile strength, and moisture content.

These are the raw materials that have been deveolped in conjunction with a processing plant which has been producing limited, but increasing, quantities of braille literature over the past two years.

The paste is pumped through a system of opposing ducts mounted inside two contra-rotating drums around which are attached 16 stencils, 8 on each drum, these stencils are perforated with holes wherever dots are required in accordance with the braille matter to be printed. The speed of the paper web is identical to the peripheral speed of the rotating drums between which it passes in contact with the stencils. The relative speed at the contact or printing position is therefore zero and at this point wherever a hole in the stencil passes over the duct, paste is injected through the hole at a pressure of 45 psi onto the paper.

Both sides of the paper are printed simultaneously at a web speed which is variable to a maximum or normal working speed of 105 ft/min, the equivalent twenty-one 16-page Sec./min.

As the linear movement of the paper and the radial motion of the stencils advance from the line of printing the two separate. Here a slight stringing of the paste occurs which results in the deposition of minute spots of paste on the outer face of the stencils. If this were allowed to accumulate, irregularly shaped dots would result due to the lack of intimate contact between stencils and paper. Provision has therefore been made for continuous cleansing of the outer stencil surfaces by means of rotating nylon brushes which revolve also in contact with a system of metering rollers. These rollers rotate in a bath of PVC plasticizer and in addition to removing the excess of paste from the brushes, apply fresh plasticizer to the brush and so onto the stencil surface for lubrication to reduce paste adhesion to a minimum. The supply of plasticizer to the metering rollers is kept clean from a simple gravity feed reservoir which collects the waste paste in a gravity sump.

The paste ducts consist, in principle, of slotted synthetic rubber tubes, the slots being held in contact with the interior surfaces of the stencils at a pressure in excess of the paste pressure to prevent leakage. The film of paste retained on the inner face of the stencils, being thixotropic, or having properties of low shear, has a low frictional coefficient at the working pressures between duct and stencil and provides an effective lubricant to reduce wear of the duct face. After considerable use, slight abrasion of this face occurs and adjustments are provided on the machine to compensate for this. Should the contact face eventually become badly worn or damaged, the design permits reconditioning by surface grinding or replacement. After leaving the printing drums the web is drawn through a nine-foot long heating chamber which is fitted with infrared sheathed wire elements above and below the web. The intensity of these elements is manually adjusted, with the aid of a remote indicating pyrometer incorporated in the chamber, to raise the paste to its gelling temperature of approximately 200 degrees C.

This heating chamber is force-ventilated to remove the vapors given off from the paste and paper.

Before printing is commenced the heaters are switched on for an initial warming up period of two minutes with cold air blowers directed along the web above and below to keep it cool. These blowers are then cut off and printing started at a speed of 5 Sec./min. As the heater radiation builds up, the machine speed is increased over a duration of three to four minutes until a continuous working speed of 21 Sec./min is reached.

As the web is printed on both sides, it is necessary to avoid disturbing the dots while they are still soft. It is therefore supported on its passage through the machine on rollers which are reduced successively in diameter to be out of contact with the braille areas. Any tendency of the web to pull into these relieved portions is prevented by bias wheels applied under spring pressure to the outer edges of the web to maintain a transverse tension. These edges and the central unprinted area of the paper are subjected to the greatest tension and are screened against direct radiation from the heaters to avoid unnecessary loss of moisture and reduction in tensile strength.

The most common criticism of the early solid dot publications was that many readers experienced a restraint or drag to the fingers after reading for a short time. Alterations to the composition of the paste to produce a harder dot largely overcame this fault but some readers still complained of a slight tackiness.

Experiments, made by dusting the printed web with various powders to reduce finger friction, proved very successful and this was incorporated in the process by the addition of spray guns which direct compressed air powder onto both sides of the web as it emerges hot from the heating chamber.

Magnesium Silicate Talc was the powder selected and after being sprayed onto the web, it is impregnated into the surface by drawing the web between stationary brushes. It then passes between cold air jets which both cool the printed web and remove any loose particles of powder.

After cooling, the web is fanfolded in a rotary unit consisting of flexible steel blades which force the paper into opposing folding jaws which snap closed to form transverse creases. The web is also guillotined in this unit by intermeshing perforator blades to separate the continuous paper into 16-page sections. As each section is cut off it is delivered by a reciprocating table onto conveyor belts and through a further unit that applies a center crease to form the spine of the untrimmed sections. These are then automatically fed onto a receiver synchronized with the machine that delivers each section down a chute to collect on a lower floor for storage pending final trimming and collation.

Incorporated in the region of the guillotine is a static eliminator for the dissipation of static charges generated on the web by the action of rapid heating and cooling and also by friction. The presence of talc on the printed web has considerably reduced those charges due to the reduced frictional coefficient of the powdered dots in contact with the mechanism while folding is in progress. Removal of these charges is necessary due to the otherwise erratic behavior of the web during the folding operation. Due to the combined effect of heat and tension, the paper undergoes a longitudinal extension and a lateral contraction on its passage through the machine, resulting in approximately .02 percent dimensional change. Adjustments are therefore provided to accommodate elongation by advancing or retarding the braille area relative to the folds and also lateral compensation to ensure that the folded sections are creased centrally.

Also provided at the delivery end of the machine is a photoelectric control which automatically shuts down the machine should a section fail to be delivered correctly from the folding unit. This is a safety measure to protect the folding and perforating mechanisms from damage.

Prior to the printing unit, the paper is power-fed from three-foot diameter reels containing sufficient paper for approximately thirty-five hundred 16-page sections or the equivalent of nearly three hours continuous machine time at maximum speed without reel changes being necessary. The web is laterally guided into the machine between mechanical guides from a free loop of paper and then over a vacuum table which applies a restraint by suction to even the tension across the 26-inch width of the web.

It then passes under a photocell which detects the occasional join that occurs in the paper. The photocell actuates a compressed air spray gun that draws a band of quick drying colored ink onto the web for a length before and after the join so that the section containing it can be readily identified and discarded at the delivery end of the machine.

A letterpress unit then prints the title and section number of the publication for the benefit of the sighted operators and collators.

The stencils are produced from 5 S.W.G. (.010 inch) zinc sheeting which together with a sheet of paper are mounted in the carriage of a specially designed transcribing machine having interlocked piercing and embossing mechanisms to produce a braille embossed paper copy together with the perforated stencil. This simultaneous formation of a brailled duplicate of the stencils has been introduced because it is the policy of the RNIB to employ blind people wherever possible and in this instance it enables blind transcribers to check their work during transcription and also enables subsequent proofreading to be undertaken by blind staff. The correction of errors is carried out on a special purpose correcting machine to which both the stencil and the paper proof are fitted. The machine has two sets of twin heads, one pair for stencil correction to pierce additional holes or to spin closed unrequired holes, the second pair for proof correction to emboss additional dots or to obliterate unrequired dots. These corrections are made simultaneously on reference to the paper proof only on which the correction instructions are recorded.

The stencils are then passed through two bench machines the first of which rolls the surface of the perforated area to smooth out the minute burrs produced by the piercing punches and also swages a rib down each side to provide for precise location on the printing drums. The second machine utilizes these ribs for forming the fixing tags by which the stencils are attached to the drums.

On assembly to the printing drums the stencils are secured around the periphery by wires which under tension clamp the stencils in close contact with the drum curvature. The stencils overlap each other with the training edge of one lapping inside the leading edge of the next to present a continuous interior surface to the printing ducts.

The number of pages comprising the sections is derived from the highest common factor, multiples of which are suitable for the range of publications to be produced. This factor must also be related to a practical diameter of the printing drums. The RNIB has selected 16 as this figure giving a printing drum diameter of 20 inches. The machine could however be designed to suit other requirements.

The arrangement of stencils around the drums depends on the number of sections and the type of publication to be produced, but which in either case will have 16 or a multiple of 16 pages. In the case of a three-section magazine where the practice is to interleave the sections, the first or outside section will be comprised of pages 1 to 8 and 40 to 48, whereas with a multisection book where the sections are assembled progressively, the section pages will be in numerical order.

Dimensionally the braille dots are .042 inch diameter at their base attachment to the paper, equal to the size of the stencil perforation. The height of dot is directly related to both the stencil thickness and viscosity of the paste, the surface tension of which pulls the injected cylinder of paste into its characteristic dome shape to produce a dot .012 inches high, 20 percent greater than the thickness of the stencils in use. Other dimensions of dot, character, and line spacing are up to standard English Interpoint sizes. These base and height dimensions are of the braille produced at present, but they could be considerably modified to suit other requirements. For instance, as an experiment, dots of 4.5 mm (.177 inch) diameter have been printed from a .010-inch thick stencil with a resulting height of dot slightly above .030 inch or 300 percent greater than the stencil thickness. This indicates that the printed sections could well incorporate diagrams of dots or other shapes of varying heights if a machine were produced to perforate the stencil in diagram form.

One feature of braille production by dot deposition is that the braille areas on opposing sides of the paper do not have to be positioned relative to each other with the same accuracy that is necessary with embossed braille because of the interference between adjacent dots. In general however, the machinery used for the solid dot process is of a higher precision than that for embossing.

After the braille sections have been delivered from the printing machine they are passed to a Müller three-knife trimmer and stitcher which has been specially modified to handle the sections. These are hand fed onto a conveyor chain which transports them into the stitching head at a rate of 1200 per hour. Six stations are available on the conveyor to accommodate magazines of from one to six sections.

From the stitcher the sections are mechanically fed spine foremost into a two-stage trimmer where the top, bottom, and fore edges are guillotined. The sections then pass into a receiver where they are removed by hand. Waste paper cuttings are directed by compressed air jets into a hopper for disposal.

In the case of magazines, the collated sections delivered from the Müller machine are ready for dispatch.

For book production a further operation is necessary to provide the additional thickness required at the spine to compensate for the bulk of the braille areas. This is achieved by folding the wide central margin to double the paper thickness, no separate material being required. A special machine is under construction for making this fold after which the sections are collated and sewn on either Bremer or Martini book-sewing machines.

The economics of the solid dot process show, as with most production plants, a decrease in unit product cost with increase in quantity output. Examples of the over-all cost of magazines as compared to that of embossed publications produced on a rotary machine of similar output rate and in similar quantities are as follows:

1. 600 copies of a 48-page magazine cost £17.0.4d. ($47.64) per embossed copy against £16.0.6d. ($44.86 per solid dot copy, a saving of 4½ percent.
2. 2500 copies of 48 pages cost £ 12.0.2d. ($33.62) per embossed copy against £10.0.8d. ($28.08) in solid dot, a saving of 11½ percent.

Further economies in solid dot will result when the process is in full production due to the more economic deployment of labor and from higher bulk purchases of raw materials.

It is to be noted that due to the greater margin requirements of the solid dot printing machine, the page areas of magazines are slightly larger than those embossed and advantage has been taken of this to include 7 percent more braille matter per page.

The RNIB produces embossed books on hand-fed platen presses each of which averages an output of four-hundred 4-page forms per hour. Comparing the complete processes of transcribing, printing, and binding, an over-all output advantage for solid dot is shown above 18 copies. Examples of these anticipated savings are 28 percent for 40 copies and 38 percent for 80 copies which include radical labor economies in collation and binding of at least 30 percent when handling 16-page multiples.

It is not possible to give precise guidance as to the cost of a solid dot installation without considering this in relation to a particular production program. It is possible however, to give the current costs in England of the individual machines that would be necessary. These are as follows:

1. Piercing machine for plate location on the transcribing machines.	£ 200	($ 560.00)
2. Transcribing machine for simultaneous stencil and proof production at approximately 1.6 stencils per hour.	£ 3060	(8568.00)
3. Stencil correcting machine.	£ 3600	(10,080.00)
4. Stencil grooving and forming machines. .	£ 500	(1400.00)
5. Solid dot printing machine producing twenty-one 16-page Sec./min excluding fume extraction.	£22,000	(61,600.00)
6. Müller combined stitching and trimming M/C.	£ 3500	(9800.00)

Additional equipment for producing books:

7. Spine forming machine..............	£ 1275	(3570.00)
8. Booksewing machine................	£ 1300	(3640.00)
9. Stencil cleaning equipment for stencil storage pending reprints.............	£ 250	(700.00)

These machines are of course designed for the particular needs of the RNIB but the principles involved with solid dot printing are, within certain limitations, sufficiently flexible to suit the needs of greater or lesser production than the existing plant. Since the first production publication in solid dot in February, 1959, the criticisms received from blind readers were carefully considered and various stages in the process have been considerably modified to its present design. Eight monthly magazines of from 1 to 6 sections are now in regular production, and two specimen books have been produced to test the suitability of the process for books as well as to obtain readers' reactions.

The printing machine, the ancillary plant for producing the stencils and the subsequent machinery for converting the printed sections into magazines or books, have been proved technically sound and with the exception of the process of transcription, where a specialized knowledge of braille is necessary, no highly skilled operators are required due to the foolproofing and safety measures incorporated. With special regard to the printing machine, a greater degree of automatic control could be introduced by the use of servo mechanisms to carry out the various adjustments that are at present manual. This refinement is not favored, however, due to the boredom that would result for the machine operators who have little enough to do once the machine is in operation.

In December, 1961, a questionnaire was sent to all subscribers of the solid dot publications. Of the 2000 replies received, 68.6 percent were in favor of solid dot braille, 26.6 percent voted unfavorably, and 4.8 percent were undecided. Of the 150 replies received from overseas 72.5 percent were favorable, 20.8 percent unfavorable, and 6.7 percent undecided.

An analysis of those voting unfavorably has isolated specific objections, the first concerns the flexibility of magazines when being read on the lap. A stiff folder is therefore to be made available for those experiencing this difficulty to provide support similar to the covers of a book. The second criticism is of the slight smell given off by the heated paper. It would be possible to include a substance with a pleasant scent in the paste and possibly in the paper, but it is doubtful whether any one scent would be acceptable to all readers, and as the number of objections on this matter is so small no action is considered necessary. Thirdly, 20 percent of the unfavorable comments representing 5 percent of the total number of replies received, commented on the dots being too small, reducing legibility and reading speed. Experiments are therefore being carried out to establish the size of dot which would be acceptable to this minority. It would be unreasonable to expect 100 percent approval for any new process because in the nature of things there is always some resistance to change. It is clear, however, from the result of this and a previous questionnaire issued in 1954 that the plastic dot is preferred by the majority of blind readers.

It has therefore been decided to initiate a program of expansion of the solid dot process with the view of including the majority of our publications at present produced by means of rotary and flat-bed platen processes. A second printing machine is now under construction together with a proportional increase in the capacity of the accompanying production plant.

Publications not planned for inclusion in the process are those leaflets and pamphlets which cannot economically be expanded into 16 pages and certain specialized textbooks for which the small quantity required, sometimes only one copy, would be quite uneconomical to produce in this way. It is however of interest to note that due to the reduction in bulk, a production economy measure is possible, since the limitation imposed by storage space enables greater quantities of solid dot books to be held in stock in the same space with a corresponding reduction in the frequency of reprints.

The early assumption that solid dot braille would be better for the blind reader because the dots are far less destructible and therefore more consistent and easier to read, has been confirmed by the majority of opinions received. The added factor of reduced bulk that has been found possible, coupled with the findings that the process, even in these early days, is comparable in production cost with that of a long-established process, must be counted as distinct advantages.

Certain principles of the printing mechanism are the subject of an international patent taken out to safeguard the interests of RNIB. It is not our intention to raise funds at the expense of any other organization for the blind interested in producing solid dot braille, and a royalty-free license will be available for those using the process. Manufacturing rights for the printing machine are however granted to a British company but the RNIB will be pleased to obtain up-to-date information on plant costs and to place at the disposal of any interested organization, the benefits of our experience with the process and to advise on its application to a particular production program.

HIGH SPEED BRAILLE EMBOSSING

CARL STREHL
Verein der blinden Geistesarbeiter, Marburg/Lahn, West Germany

The subject of my report is high speed embossing. I shall mention the process of braille embossing, and also the speeds at which embossing can be done on metal plates. The process called stereotyping consists in the embossing of characters or symbols of the braille system on a folded metal sheet (of brass, zinc, or iron) cell by cell, line by line, in the interline or interpoint system. This latter refers to the method of spacing the lines of braille on one side of the reading matter so that additional cells can be embossed on the reverse side between points.

During the period of 1888 through 1892, Hall in Philadelphia (United States) and Kull in Berlin (Germany) developed both a braille sheet typewriter and a braille stereotyper. The first stereotyper made in Germany consisted of a table on which a small metal plate was mounted. One line of braille was punched on the sheet in negative form, i.e., with braille cell holes. The metal plate to be embossed was set above the braille line and over both a rule was laid of rectangular squares of braille cell size. An embossing stylus, fixed in a holding device, could be moved on a rack both downward and from right to left over the assembly. The embossing stylus had to be set at a given point and a foot pedal depressed, whereupon the first dot of the braille cell was embossed on the metal. Each dot of the braille cell had to be printed in a similar way (i.e., negatively), with the embossing stylus operating downward and from right to left. When the line was done, the plate was moved one line to the rear, and the next line was brought into embossing position. When the whole side was finished, the plate would have to be removed, reversed, and put back again. The positive printing on the reverse side could now be read. The folded metal plate could only be embossed, however, on one side.

This was a time-consuming but quite practicable method for making printing plates for braille books and magazines. A skilled operator could emboss no more than half a page per hour in the standard book size, i.e., 28 lines of 36 cells each.

In the early nineteen hundreds modern stereotyping machines were designed and built in England, Germany, and the United States. At the end of World War I some of these machines were made at the American Braille Press in Paris (the organization which was later to become the American Foundation for Overseas Blind). In these machines, folded metal plates were mounted into a holder or frame and either hung vertically or placed horizontally on the machine. The earliest models were operated by a system of levers and the pressure of the foot of the operator; the later models were equipped with motor drives. Plate movement is automatic in these machines, and they produce doublesided interline or interpoint prints. Each page contains between 23 and 32 lines of 36 to 42 cells, depending on whether the requirement is for small or for large pages. Most stereotypers are equipped with but one braille type standard; some are equipped with small, medium, and large size type.

A skilled operator can emboss between two and one-half and four doublesided plates per hour, depending largely on the complexity of the subject matter; the lower figure would hold for scientific material which requires special symbols and/or which includes figures, and the higher figure for discursive text (as for fiction, etc.). An interpointed brailled page contains about 1000 cells. One operator will be able, therefore, to produce copy at the rate of 8000 cells per hour, including both characters and spaces between characters, of braille with contractions. As far as I know this is the highest embossing speed reached by operators of standard stereotyping machines in current use. In an eight-hour working day the operator will produce 32 plates (64 pages), and in a full five-day working week he will emboss perhaps 160 plates (320 pages). A braille printing plant having six stereotyping machines thus could emboss 1920 pages or so per week. In my opinion this production rate would not be sufficient for countries with 3000 to 10,000 visually impaired braille readers; this is particularly so if flat-bed presses are available for books and rotary presses for printing magazines.

Ordinary flat-bed (Victoria) presses are used for short production runs, especially for books. Such a press can print 400 to 600 sheets of braille material per hour; each sheet contains four braille pages. For longer production runs rotary presses are in common use in the United States and in many European countries. These presses operate within the range of 5000 to 8000 cycles an hour and produce one braille sheet of four braille pages per cycle.

Braille stereotyping machines are now made in several countries; among those known to me I would include:

1. England: B. J. Lynes, Ltd., London
2. Germany: Blindenstudienanstalt, Marburg/Lahn
3. Japan: Nakamura Braille Manufacturing Co., Tokyo, Kobayashi Iron Factory, Tokyo (Both distributed by Nippon Lighthouse for the Blind, Osaka)
4. United States: American Printing House, Louisville (Kentucky), Howe Press of Perkins School, Watertown (Massachusetts), Braille Institute of America, Los Angeles (California).

The original French machine, although still used in some printing plants, is no longer manufactured.

Regular flat-bed and rotary presses can be adapted for printing braille. A special rotary press for printing braille is made, however, by the Blindenstudienanstalt in Marburg/Lahn.

The most modern developments of solid dot braille and automatic machine translation of braille are intensely interesting. I have the feeling that the solid dot process will not necessarily yield higher production rates than the standard stereotyping machine; the whole text must first be written on a master, made in a braillewriting machine, which must then be transcribed onto stencils. The printing process is itself quite fast, however, producing about 1320 sections of 16 braille pages each per hour.

The automatic translation of braille involves transcribing text onto punched cards which are used as a data storage for an electronic computer, whose memory contains the contracted forms of braille notation. This is a complicated system but it is very rapid in its production of plates; it can reproduce text at the rate of 4000 words a minute.

Both systems are excellent examples of special designs, and suit admirably the purposes of one or more countries ready to produce braille in large quantities, especially under cooperative arrangements. The translation process might be too costly for short production runs. For lack of sufficient experience with it, I cannot at this time answer the question of whether the quality of solid dot braille corresponds fully to standard braille print, nor whether it meets in fact the approval of a majority of braille readers.

THE TECHNOLOGICAL ORIGIN AND DEVELOPMENT OF MECHANICAL WRITING DEVICES FOR THE BLIND

HARRY J. FRIEDMAN
Howe Press of Perkins School for the Blind
Watertown, Massachusetts

The advent of mechanical brailling, it may be said, was second only in importance to the invention and development of braille itself. The establishment of braille as a reading method for the blind was in fact resisted strongly by the already established raised print (or Boston Line Type) system. Though raised print could be read with surprising speed and accuracy, it had the additional value of enabling a sighted observer (and in many instances benefactors of the blind who witnessed reading demonstrations on exhibition at the various schools for the blind, legislature representatives determining the needs of the blind, civic groups and the like) to follow with his eyes what the blind reader was scanning, and thereby impress him with the genuineness and authenticity of the value of Line Type reading. Braille, on the other hand, though more rapidly read, did not particularly impress sighted visitors to reading demonstrations because all that the finger was doing was reading with a system of dots not having much intrinsic interest or fascination for the observers. This partisan regard for Line Type reading, both by the public and by educators of the blind, kept braille in the background and denied it its rightful place as a superior finger reading method. It was not until some 50 years later (and not until it was acknowledged that braille could be written as well as read) that braille was finally selected and adopted as a universally approved reading technique for the blind. The final and deciding factor in this recognition was the fact that braille could be written by sightless individuals; this was not possible with raised Line Type except at prohibitive cost. Writing braille was first demonstrated with the familiar slate and stylus such as that employed now. Slate-and-stylus writing is actually still used widely throughout the world. Satisfactory and advantageous though this method is, the need for a swifter, easier, and more accurate way of writing soon became apparent.

In 1850 the first writing device was introduced. Since that time there has been a succession of braille writing machines produced here in the U.S.A. and abroad. Each has contributed to the technological development of the mechanical braillewriter.

On the following pages the reader will find a photographic essay of the development of the mechanical braillewriter on historical lines. Each machine is identified by a Figure number; the text describing the braillewriter will contain the same Figure number.

The author wishes to acknowledge the loan of braillewriters from Mr. Paul Langan, of the American Foundation for the Blind, and Mr. Virgil Zickel, of the American Printing House. Many thanks are due Mr. Roy Dozois and Mr. Albert Czub of the Howe Press of Perkins School for the Blind for their assistance in the preparation of technical data that accompany each Figure.

The author will also be grateful to readers who can fill in missing data or correct errors in this survey. Until additions and any necessary corrections have been incorporated into this text, our efforts should be considered tentative and incomplete. Every reasonable caution has been exercised, however, to ensure completeness and accuracy.

The Wight writer was perfected by Mr. Joel Wight, whose wife was a teacher at the Perkins School. One of her pupils was Laura Bridgman. This device is believed to be one of the first mechanical writing devices (circa 1850). It is the oldest braillewriter in the Perkins Museum (Figure 1).

The sheet of braille paper is contained in the carrier frame (the inner frame with the cloth matrix). The sheet of paper used measures 6 inches by 8 inches. Line spacing is achieved by squeezing the two levers in the upper left-hand side of the frame; this movement advances the carrier one line. Cell spacing is effected by pushing the lever immediately to the left of the white card. It is interesting to observe that on this model, which is more than 100 years old, the rack principle for advancement of the carriage cell is almost identical to present-day methods of carriage spacing. The nine pearl button keys produce “nine pin prick” dots in one cell. The braille cell contains dots in a three-by-three configuration. The single pearl button is a cell spacer key.

The Wight writer operates from left to right.

In 1865 Mr. Joel Smith of the Perkins School invented a device to write “American braille.” The name Daisy (or Star) Point writer is at-

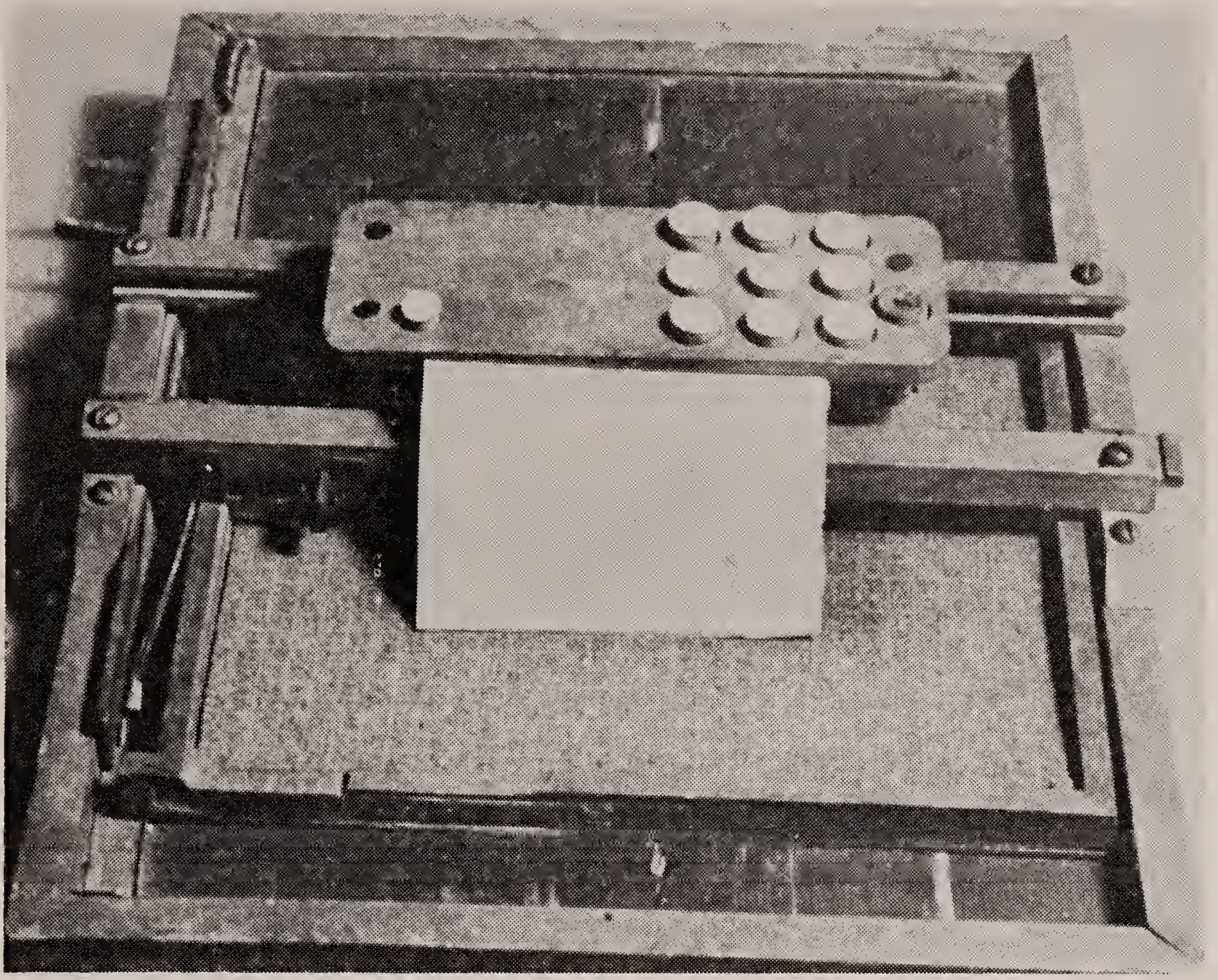

FIGURE 1 The Wight Writer

tributed to the daisy or star-like effect created by the cluster of keys on the embossing carriage (Figure 2).

Line spacing and cell spacing are both performed by freehand movement. On the right side of the frame is a notched rod that passes from top to bottom and allows for accurate line spacing. Paper is inserted into the writer by lifting the frame containing the daisy head and guide rods (the frame is hinged on the top). This writer uses a 9-inch by 11-inch sheet of paper. The matrix is composed of a cloth covering with padding beneath to receive the pressure from the braille formation.

Figure 3 is an improved version (1880) of the Daisy writer, as evidenced by the following changes:

1. A paper feeding mechanism, and a knurled paper feed roller on each side of the frame, are both included.
2. The operator is able to space each line uniformly by a detent system in the paper feed roller.
3. Individual cell spacing is accomplished by the operator moving the embossing head from cell to cell.

The over-all length of the writer is 9 inches.

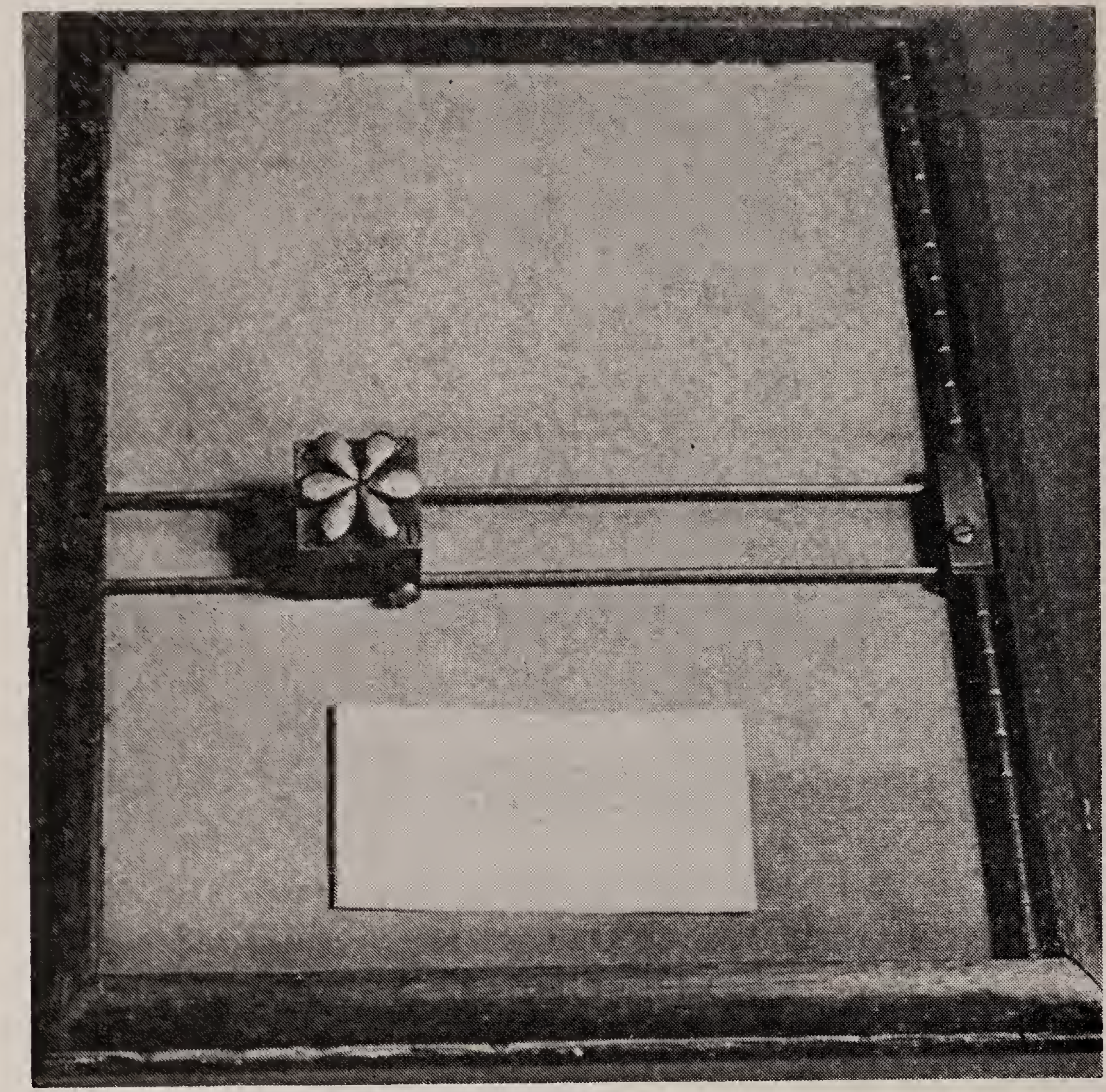

FIGURE 2 The Daisy Point Writer

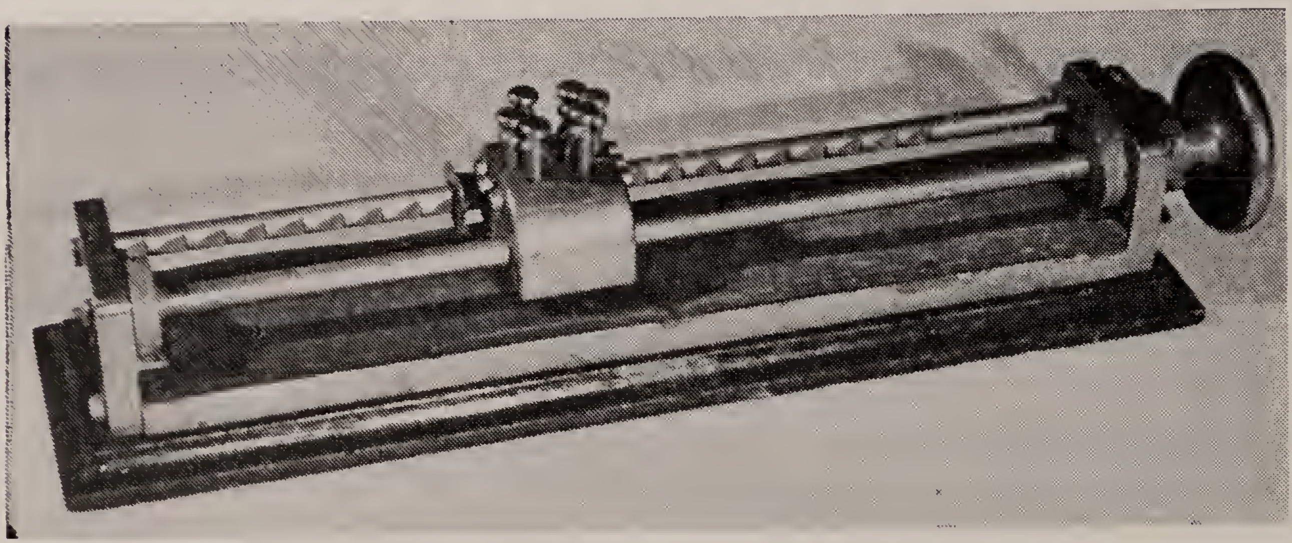

FIGURE 3 An Improved Daisy Point Writer (Inventor Unknown)

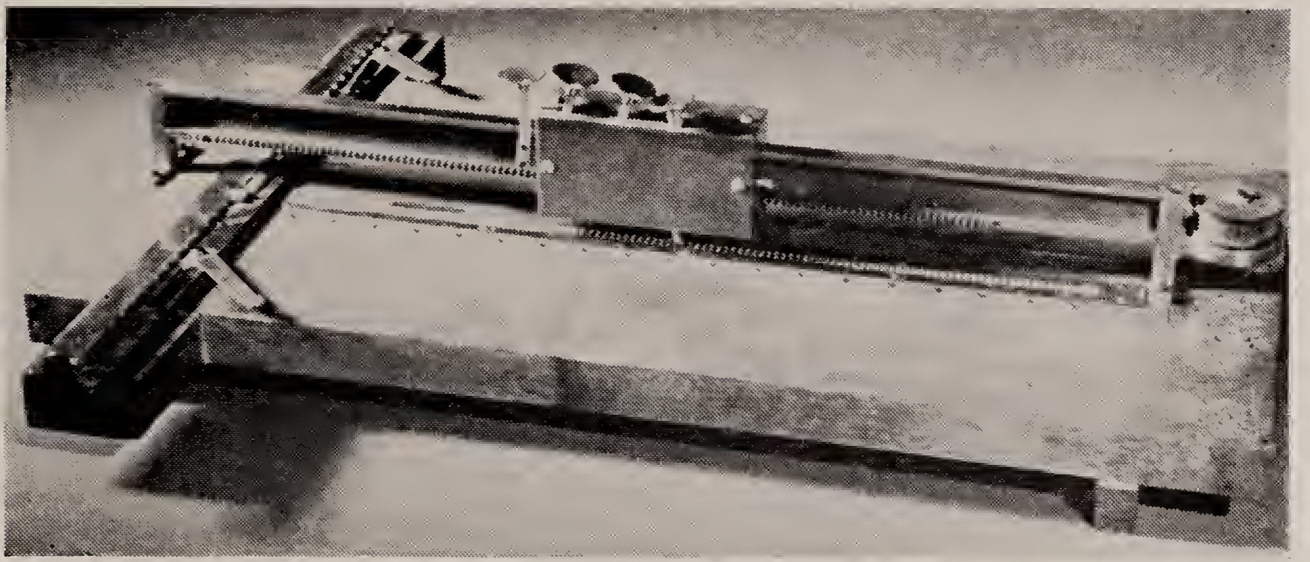

FIGURE 4 The Punctograph

A New York Point writer was introduced in Louisville, Kentucky about 1885. The Punctograph was one of the earliest upward writing devices (Figure 4).

Uniform line spacing and cell spacing can be obtained with this writer with the combination metal carrier on the left side of the wooden frame. The detent mechanism is visible. The two arms that are swung out illustrate the paper clamping device that is also incorporated with the line spacing mechanism. The key on the far left of the carriage is for cell spacing. Maximum size paper used is 9 inches by 11 inches. The wooden pulley on the extreme right side of the cell spacer bar is the means used to move the embossing carriage from left to right. The matrix consists of a strip of copper secured to the entire length of the wooden base on which the braille is embossed (two dots high per cell). The two keys are hollow styli, and braille is produced when the hollow styli forces the paper onto the formed braille matrix.

The Unigraph dates back to 1890 and was designed to write either American braille or New York Point braille (Figure 5).

The Unigraph is 10 inches long, 5 inches wide, and uses a 9-inch wide

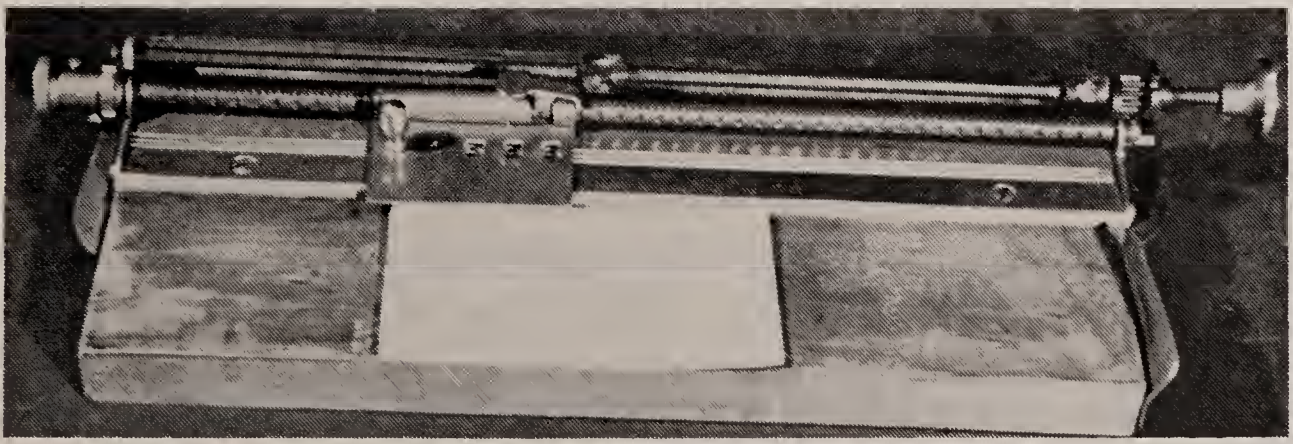

FIGURE 5 The Unigraph

sheet of paper. Brailling is accomplished by a hand-held stylus, as with a hand slate. Proper orientation of the machine for either New York Point or American braille is accomplished by shifting the knob on the left side of the writer. This control knob, when rotated one quarter turn, changes the spacing from the full cell of American braille to the half cell of New York Point. The cell spacing lever is directly above the braille cell opening. The matrix of the Unigraph consists of three grooves passing along the entire length of the base assembly. These grooves accept the shape and force of the formed braille. The operator controls proper line spacing by the paper feed knob on the right side of the machine.

The Unigraph operates from left to right.

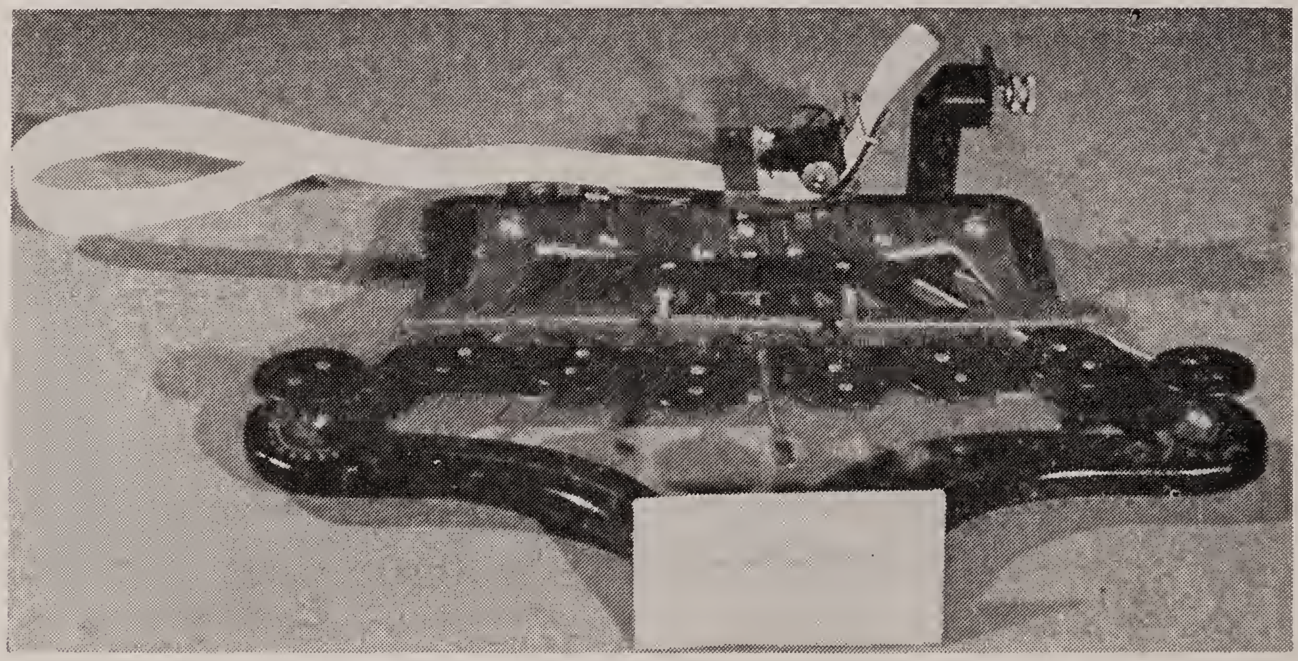

Figure 6 The German Pocket Writer

Figure 6 was made about 1890 and uses paper tape. It is portable (weight: 2 pounds). The tape used in the writer is ½ inch wide.

Note that four separate positions are available for producing cell spacing:

1. To the extreme right or left of the keyboard
2. With a center cell spacing key in the keyboard, and with one bar key above the keyboard.

Figure 7 was made in Chicago, Illinois about 1890. The machine weighs 3½ pounds. It has only three braille keys and a cell spacer.

When writing American braille all three keys are used, writing half a cell at a time. The cell spacer key moves the carriage at half spaces. The paper is inserted from the rear between the two rubber rollers. Maximum width of paper used is 8 inches.

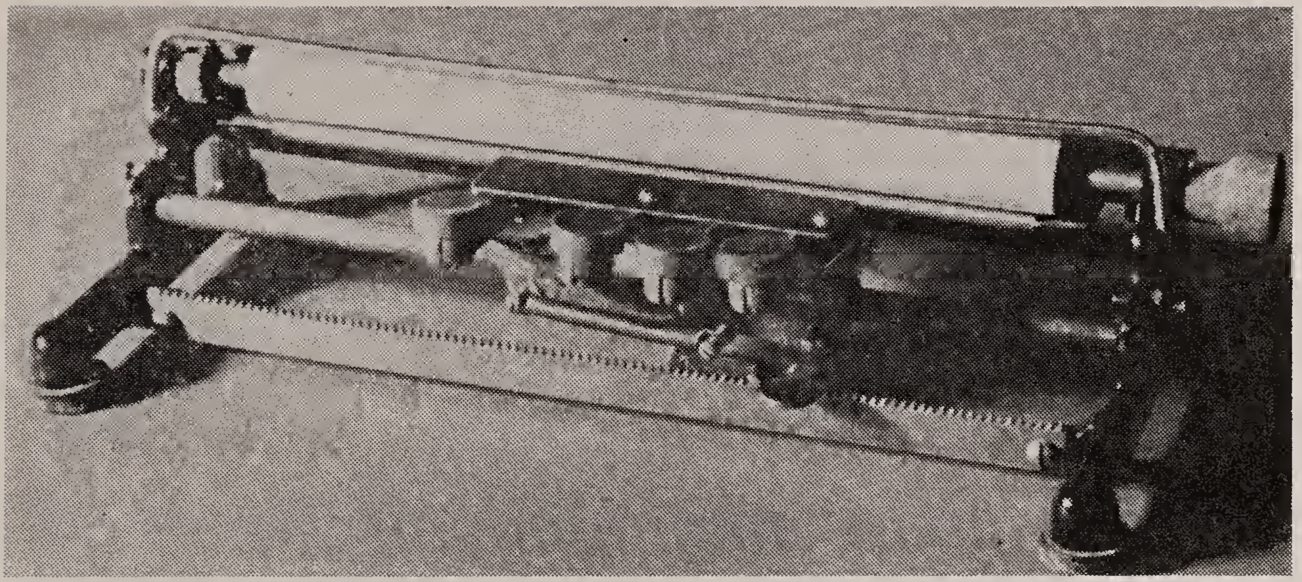

FIGURE 7 The Seifried Midget Braille and New York Point Writer

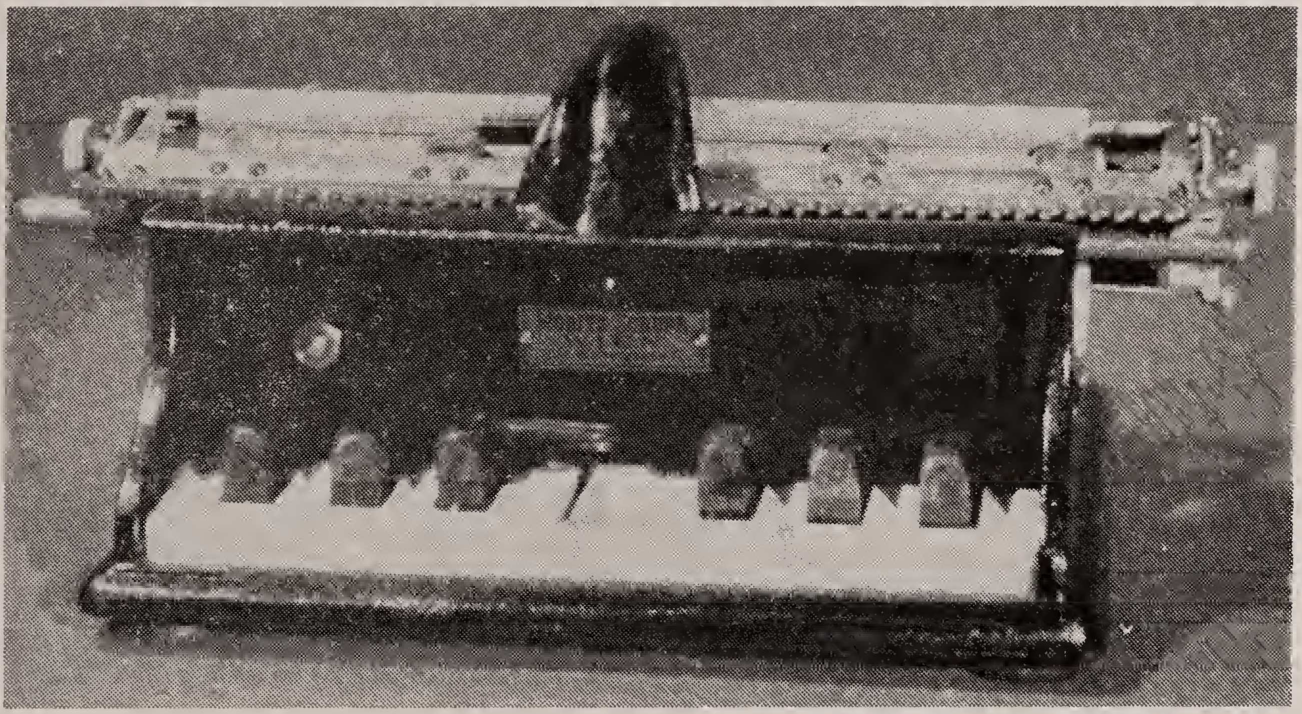

FIGURE 8 The Hall Writer

The Hall writer was introduced on May 27, 1892 in Jacksonville, Illinois. Mr. Frank Hall, the Superintendent of the Illinois School for the Blind, was the inventor (Figure 8).

The paper used is 11 inches wide, and is inserted from the rear after passing between two rubber-covered feed rollers. The paper is then stored inside a hollow drum.

The Hall writer was available throughout Europe in the early nineteen hundreds. (Note that the model in Figure 8 carries a German identification plate.)

On January 5, 1893, Mr. Hall demonstrated the first stereotyper. By embossing braille on a thin brass sheet, which then served as a master, he fitted

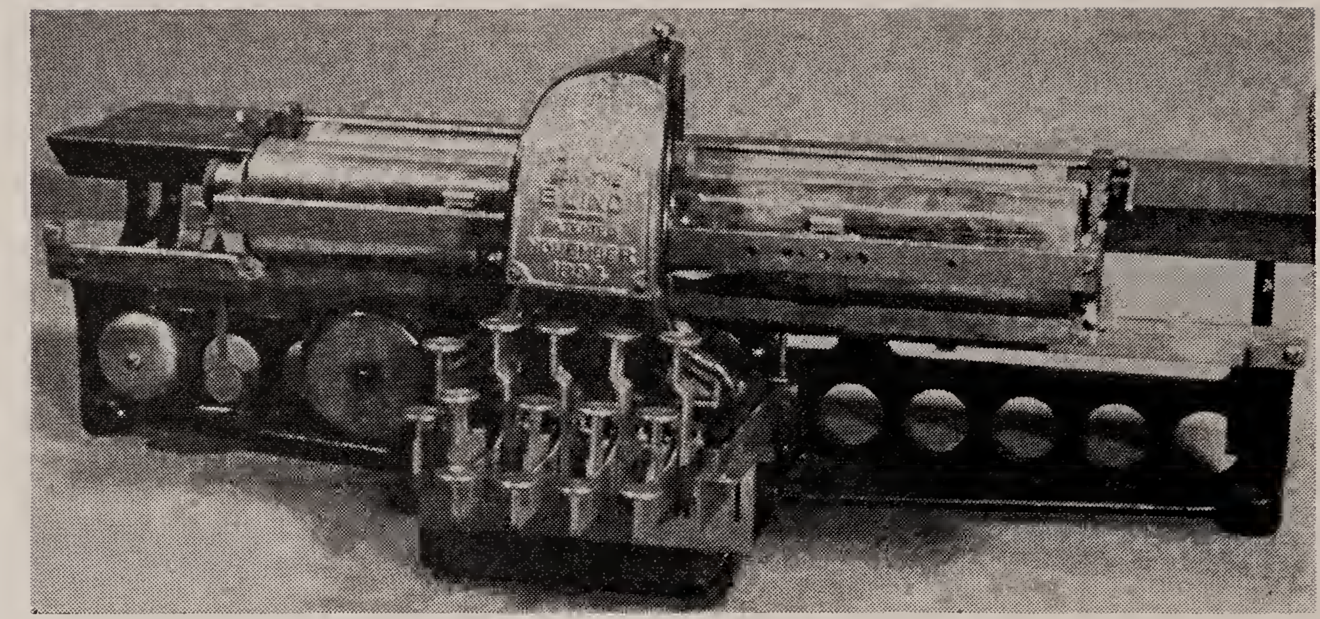

FIGURE 9 The Kleidograph

the master into a hand press; when paper was placed over the brass plate and pressure applied the braille characters were transferred to the paper.

The Kleidograph was patented by The New York Institution for the Blind in November, 1894. It weighs 15 pounds and writes only New York Point braille (Figure 9).

The cluster of 12 keys and cell spacer bar make up an unusual keyboard arrangement. The paper is inserted from the rear and rolled around the paper drum.

Operation of the Kleidograph: The carriage must be moved over to the extreme right. The keys in the top row are 1-, 3-, 5-, and 7-dot keys; those in the middle row are 2-, 4-, 6-, and 8-dot keys. The lower row keys consist of compounds, that is, combinations of 1- and 2-, 3- and 4-, 5- and 6-, 7- and 8-dot keys.

The two keys at the lower left side are set down from the other keys. These keys are for capitals and produce a larger point. Any character, or combination of points, can be made using them.

At the completion of a written line of New York Point, the carriage is at the extreme left position. To advance the paper for the next line the lever to the left of the paper drum is moved to the forward position. This movement automatically advances the paper one line.

A very small adaptation of the conventional writing machine was made in Germany about 1900. It was called a pocket braillewriter. The writer weighs about 4 pounds. This machine incorporates the conventional keyboard and the keys are made of white ivory (Figure 10).

The paper measures 5 inches in width, is fed into the writer between the two rubber feed rollers, and is stored inside the stationary hollow drum.

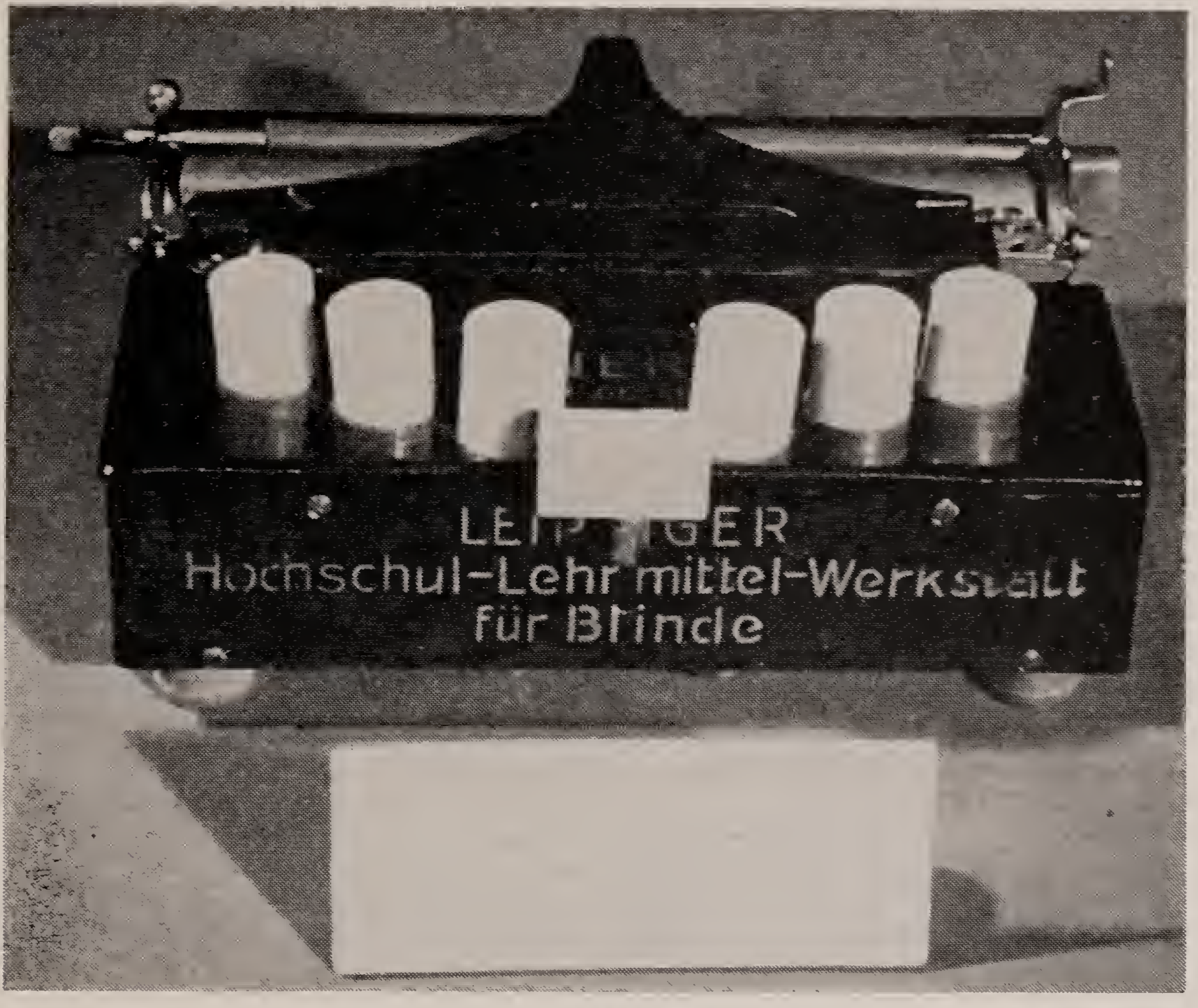

FIGURE 10 The Minerva

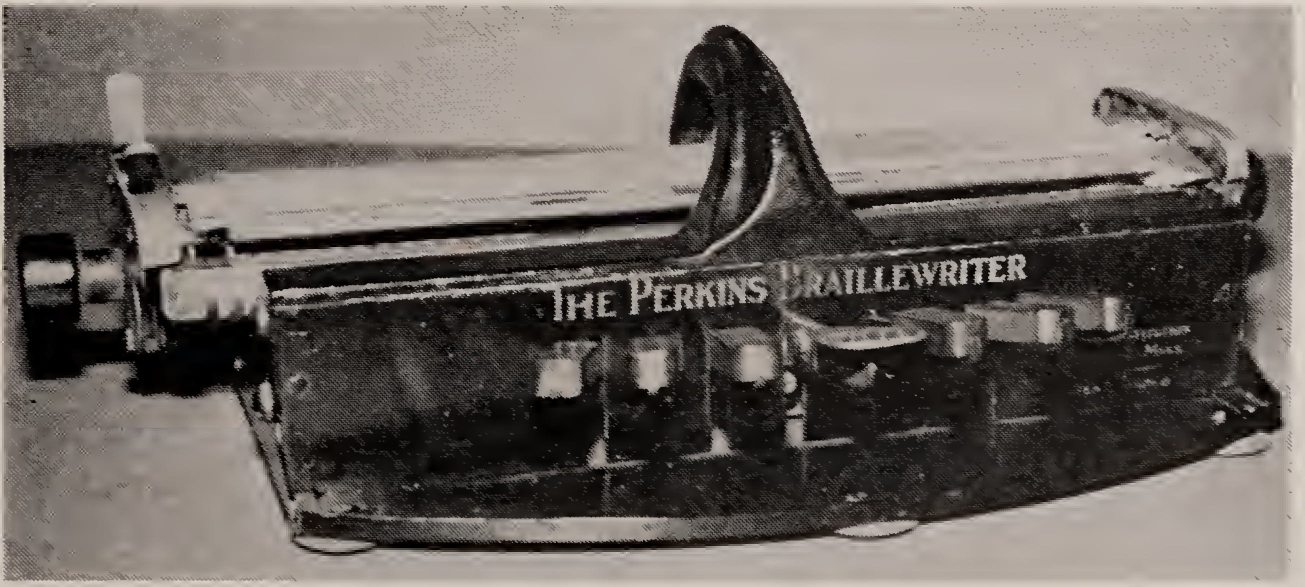

FIGURE 11 The Perkins Braillewriter, Model C

Figure 11 was made about 1900. It weighs approximately 9 pounds. It has six conventional keys and a spacing key (located in the center). The spacing key must be depressed to move the carriage left or right. It is equipped with two feed knobs made of wood and line spacing levers which are mounted at the extreme left of the carriage unit. Squeezing the two levers advances the paper one space. There are right- and left-margin stops

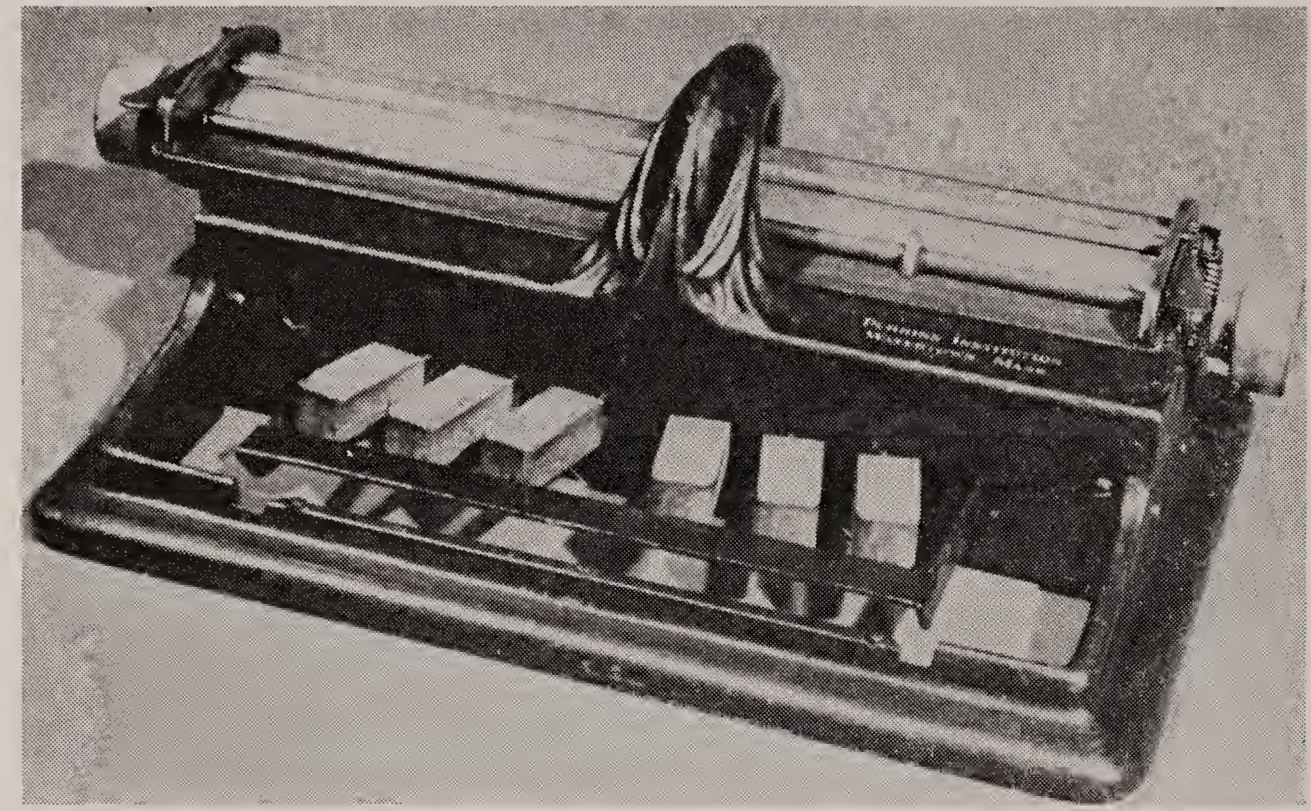

Figure 12 The Perkins Writing Machine

located at the front of the carriage. The paper is fed between a wooden roller and a steel knurled roller. The paper rolls around the wooden roller inside a stationary drum. There is a bell to alert the operator when the end of the line is reached.

The Perkins writer was introduced by the Perkins School in early 1905. It weighs 10 pounds (Figure 12).

This writer uses a 9-inch wide sheet of paper which is inserted from the

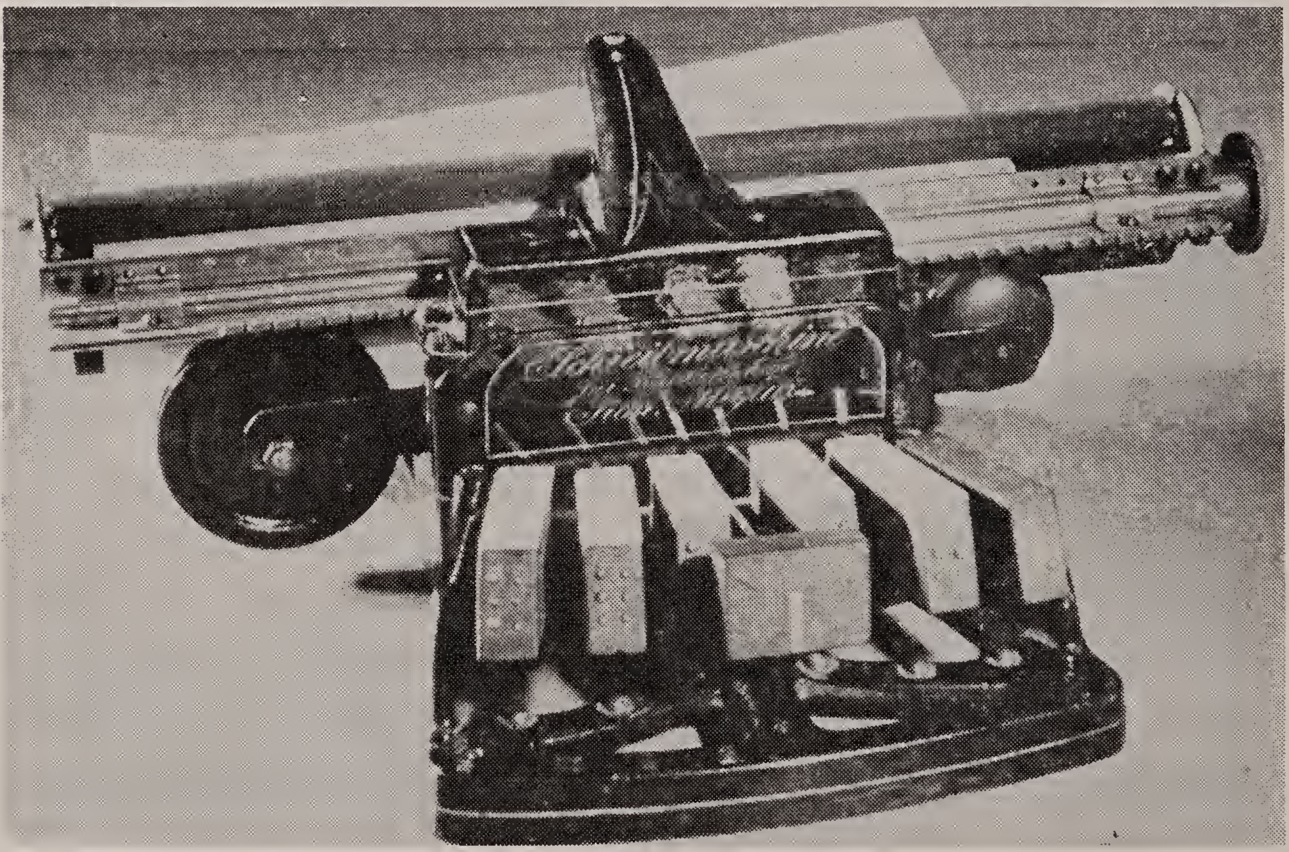

Figure 13 The Picht Braillewriter (Fast Writing Machine)

rear between metal rollers. The paper is wound into a stationary hollow metal drum.

The machine possesses a few of the now standard features of all braillewriters, as for example:

1. Space bar assembly
2. Paper feed knobs on both sides of the machine
3. Rapid traverse carriage release lever
4. Conventional keyboard.

The Schnellschreibmaschine was invented by Oscar Picht, the Director of the Provincial School for the Blind in Bromberg, Germany, about 1900.

The weight of the Picht writer is 8½ pounds. Nine-inch wide paper is used, and the paper is stored around a solid wooden drum. The top of each key is covered with ivory, while the front face of each key has a full braille cell with one larger dot emphasizing the correct key number (Figure 13).

The Boston Braillewriter (Figure 14) was produced in 1910.

The writer uses a flat, 11-inch wide sheet of paper, which is fed through two rubber rollers into a slot in the largest roller (which acts as the paper drum). One innovation introduced by this machine is a carriage release lever located in the front (to the right of the gooseneck). This model also

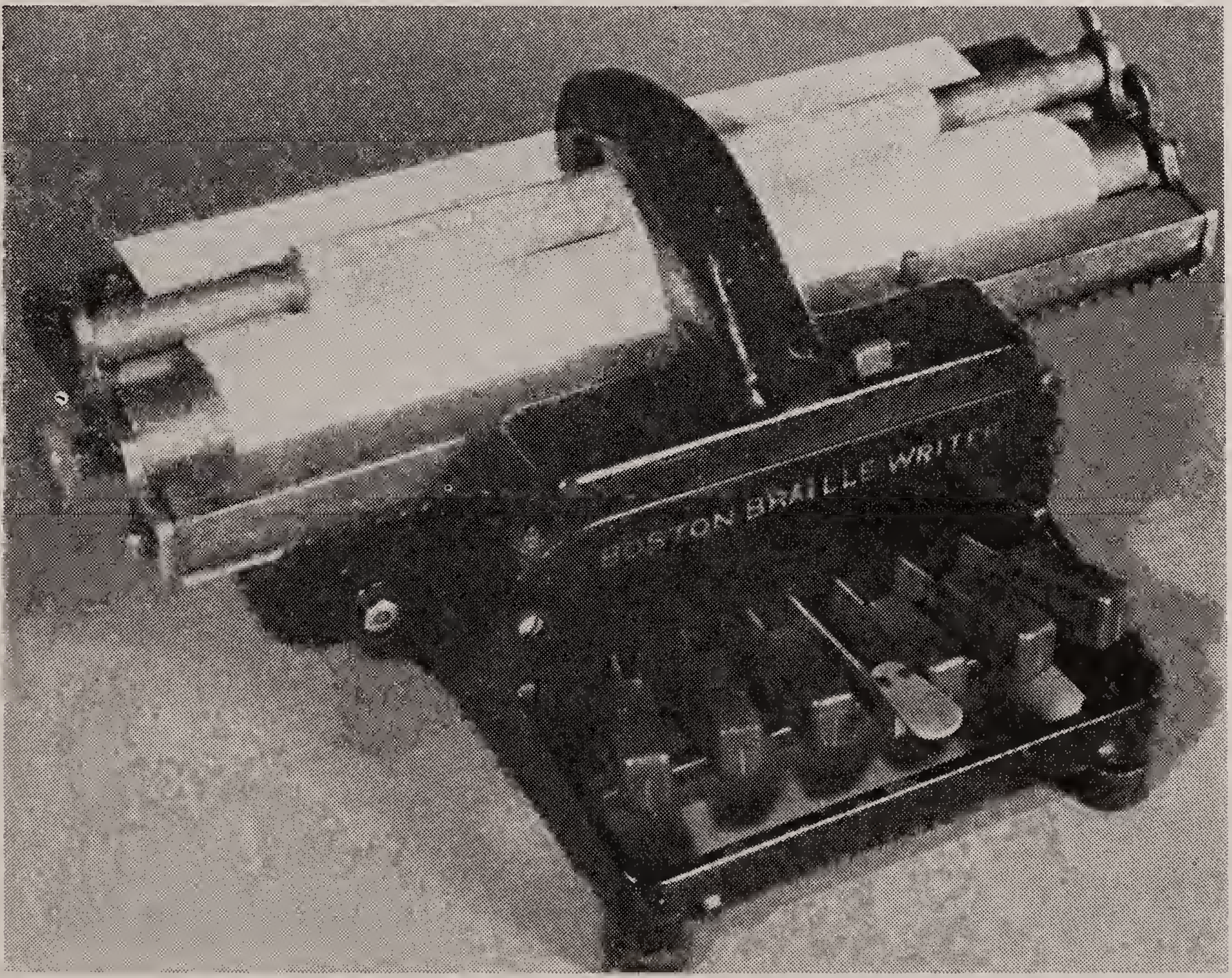

FIGURE 14 The Boston Braillewriter

introduced the first self-operating carriage feeding mechanism. The flat spring is housed in the pancake disc on the left side of the writer (under the carriage).

The weight of the writer is approximately 8 pounds.

About this time the name "Perkins Braillewriter" was changed to the "Boston Braillewriter." But the name "Boston Braillewriter" was dropped soon after, and the original name was restored to the machine.

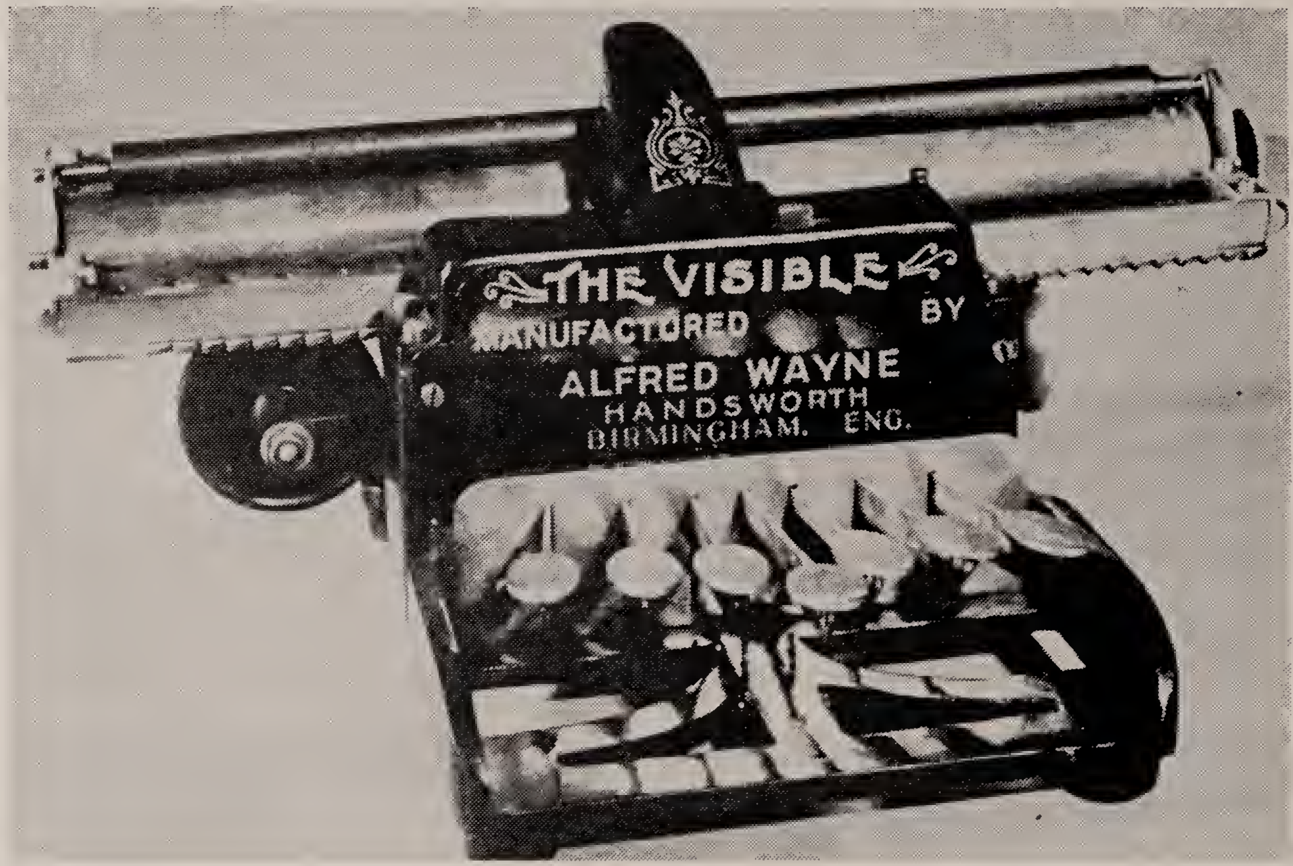

Figure 15 The Visible Writer

The Alfred Wayne ("Visible") writer was made in Birmingham, England, about 1912. It has many characteristics similiar to the "Boston Braillewriter" (Figure 15).

Figure 16 was made by Stainsby/Wayne, in England, about 1910. It weighs approximately 4 pounds, and uses regular 11-inch paper.

The paper is secured under the paper clamp at the top of the board, and slips under the guide rails of the cell spacing mechanism, which is completely self-contained. The writer operates from right to left. The base is made of wood 12 inches wide and 14 inches long, and is hinged to facilitate easy storage. The braille from this writer is formed downward, as with a slate.

From the appearance of the wooden base assembly, and the relationship of the holes, this writer was capable of interpointing. At the completion of each line of braille, the operator lowers the entire assembly down, one line at a time, on the wooden base.

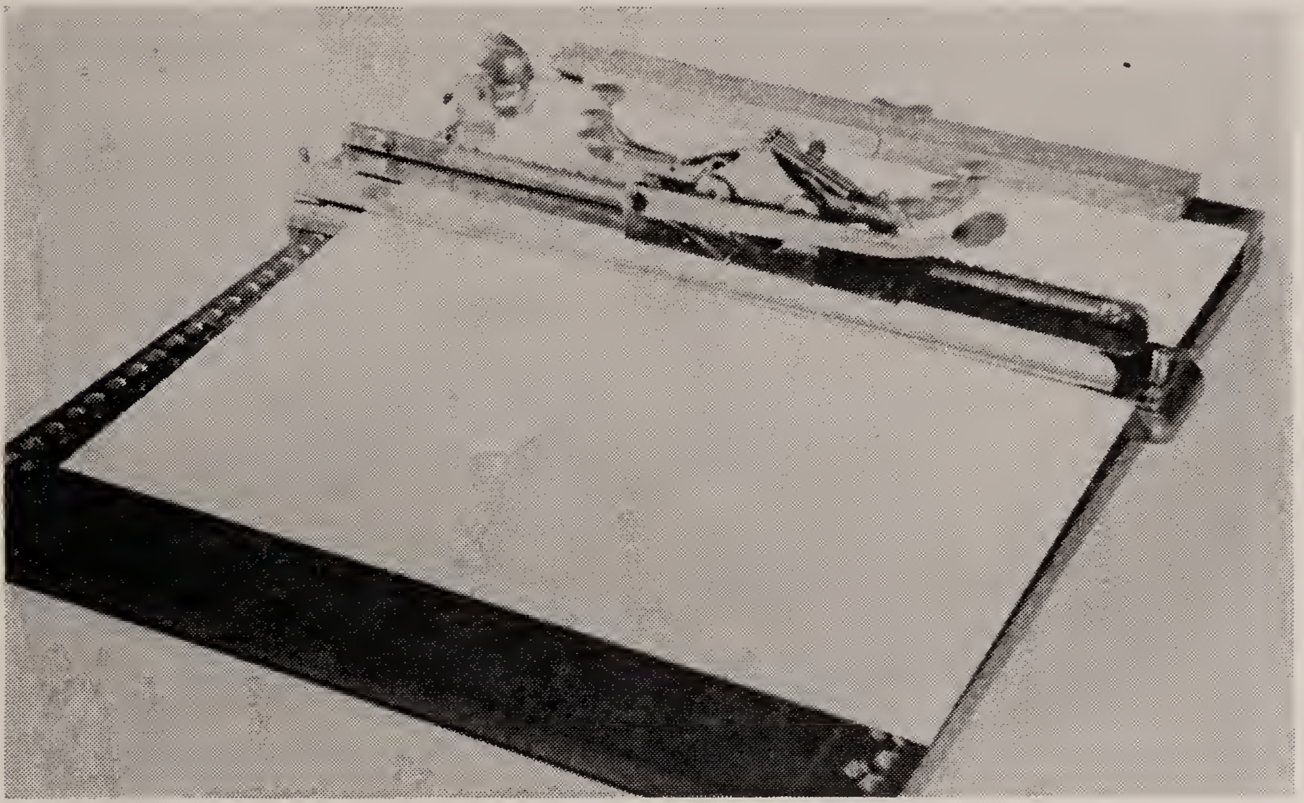

Figure 16 The Stainsby Berridge Braillewriter

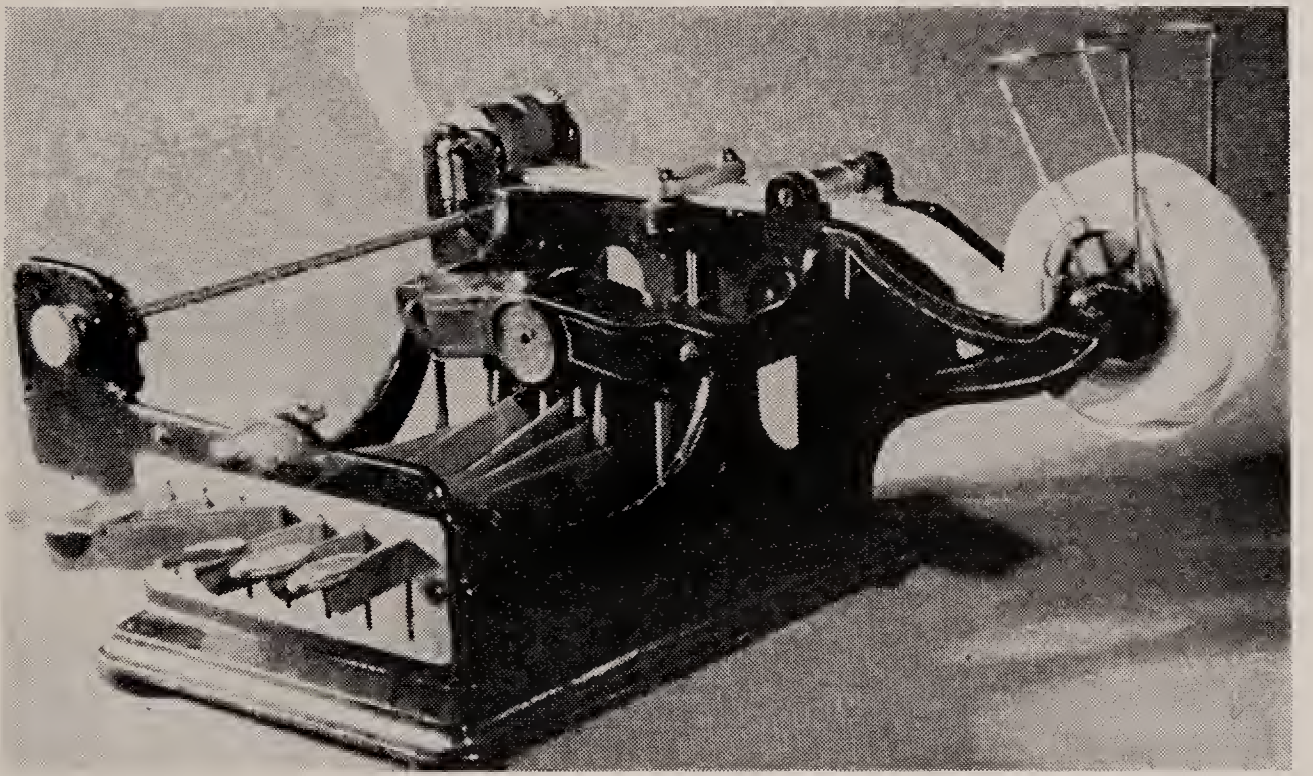

Figure 17 The Stainsby Shorthand Writer

A portable shorthand writer appeared about 50 years ago. It weighs about 10 pounds, and has a standard keyboard (Figure 17).

Paper rolls $\frac{15}{16}$ of an inch wide are used. A signalling device alerts the operator of the need for a fresh supply of paper. The paper feeding mechanism is located on the left side of the machine. This device advances the paper cell by cell via the movement of keys or the spacer bar.

The Stainsby is a truly portable model which can be carried in its companion wooden case.

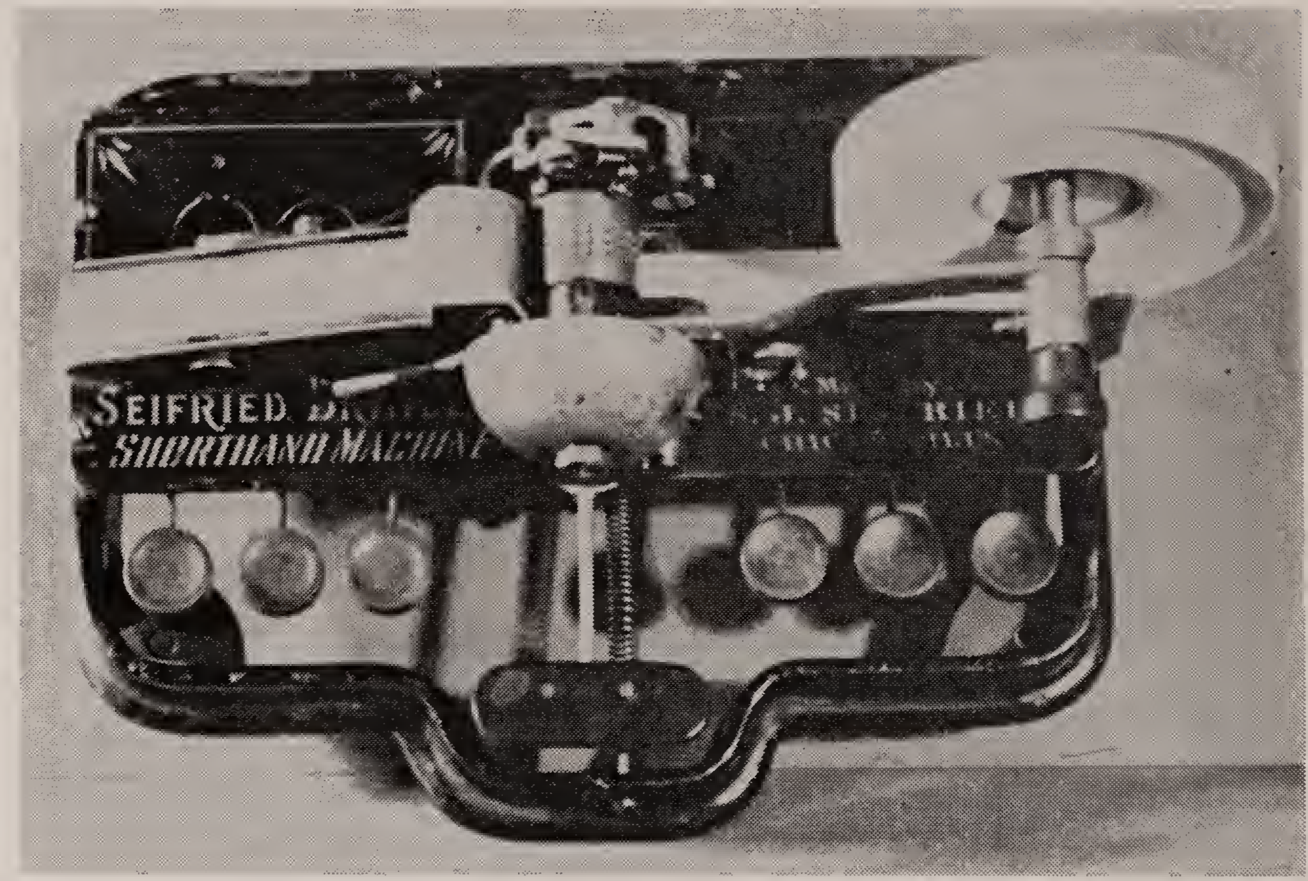

FIGURE 18 The Seifried Shorthand Machine

The Seifried Shorthand writer was made in Chicago, Illinois, about 50 years ago. It weighs $4\frac{1}{2}$ pounds (Figure 18).

The machine was intended for taking notes in braille on a roll of paper tape. It incorporates the unique approach of using a die assembly as a paper feed roller. Another clever idea is the arrangement whereby, when the paper reaches a certain minimum amount, it trips a bell automatically.

Figure 19 is a braillewriting device whose source we have been unable to identify. The machine has some interesting features which may cause us to wonder a little about its vintage. For example, there is only one paper feed knob; the paper drum is a hollow tube around which the paper is rolled; and the braille produced has six vertical dots in a single line $\frac{3}{8}$ of an inch high.

The machine is manually operated. The ratcheted feeding arrangement which you see is the only means for power coupling. As a key or the space bar is depressed, it automatically engages a new tooth on the ratchet; as the key returns to its normal position, the carriage moves ahead $\frac{3}{32}$ of an inch.

The Pyke Glauser writer is about 40 years old. It weighs 11 pounds. It is powered by a flat clock spring (under the bell in the foreground). It will write 36 cells of braille (Figure 20).

Paper is fed downward from the rear of the machine and secured between the paper clamps, brought forward manually line by line. The pins of the paper clamp fit into the visible holes in the metal table and provide accurate spacing for each line. Interpointing is possible by turning the paper over

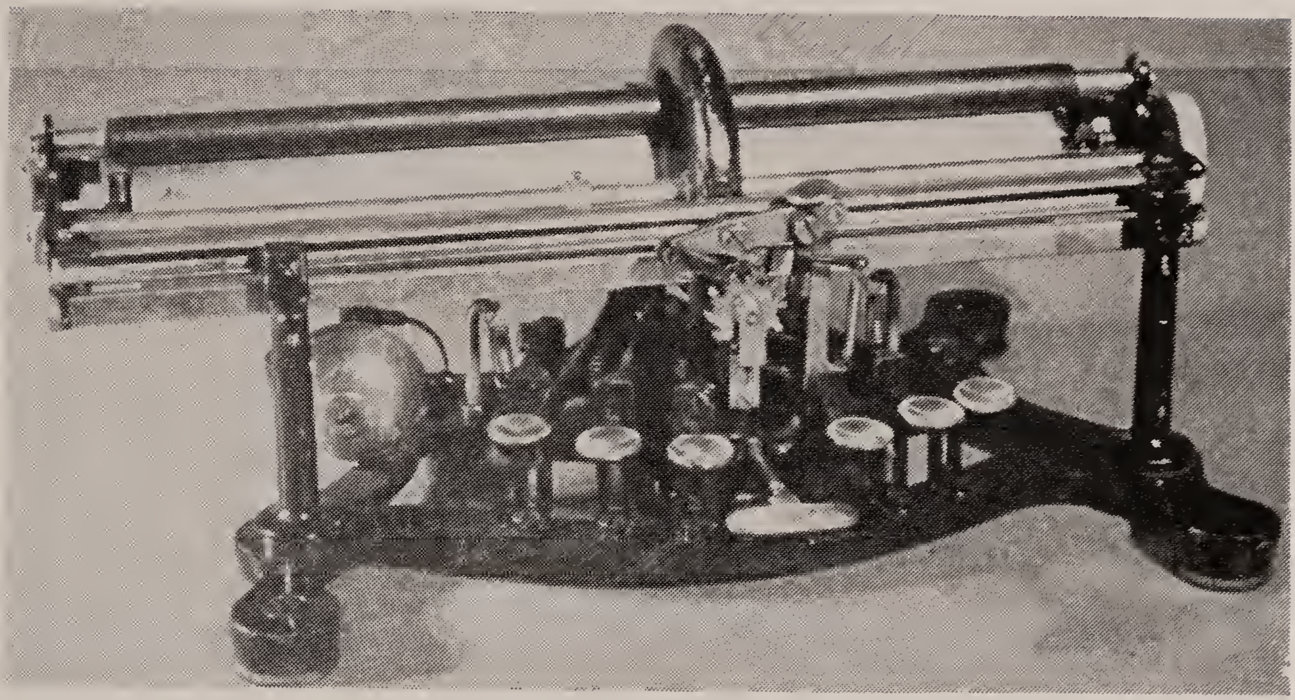

FIGURE 19 Braillewriter of Unknown Source

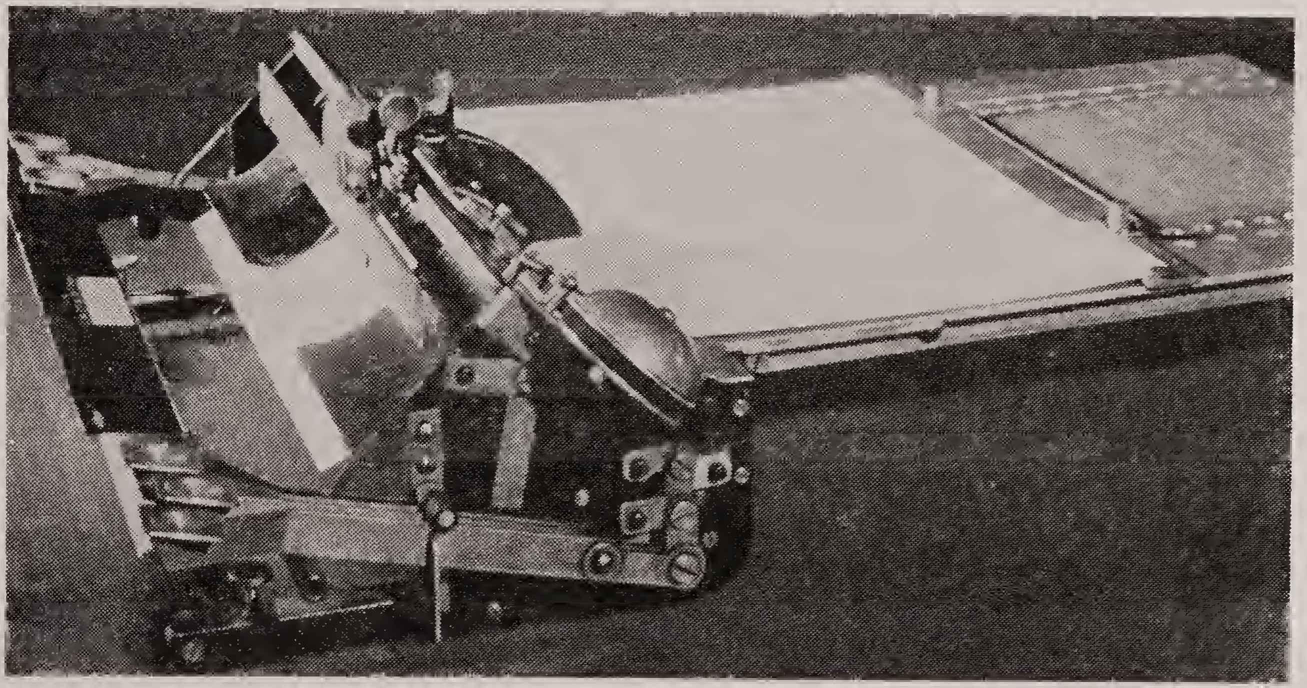

FIGURE 20 The Pyke Glauser Braillewriter, Model PG 55

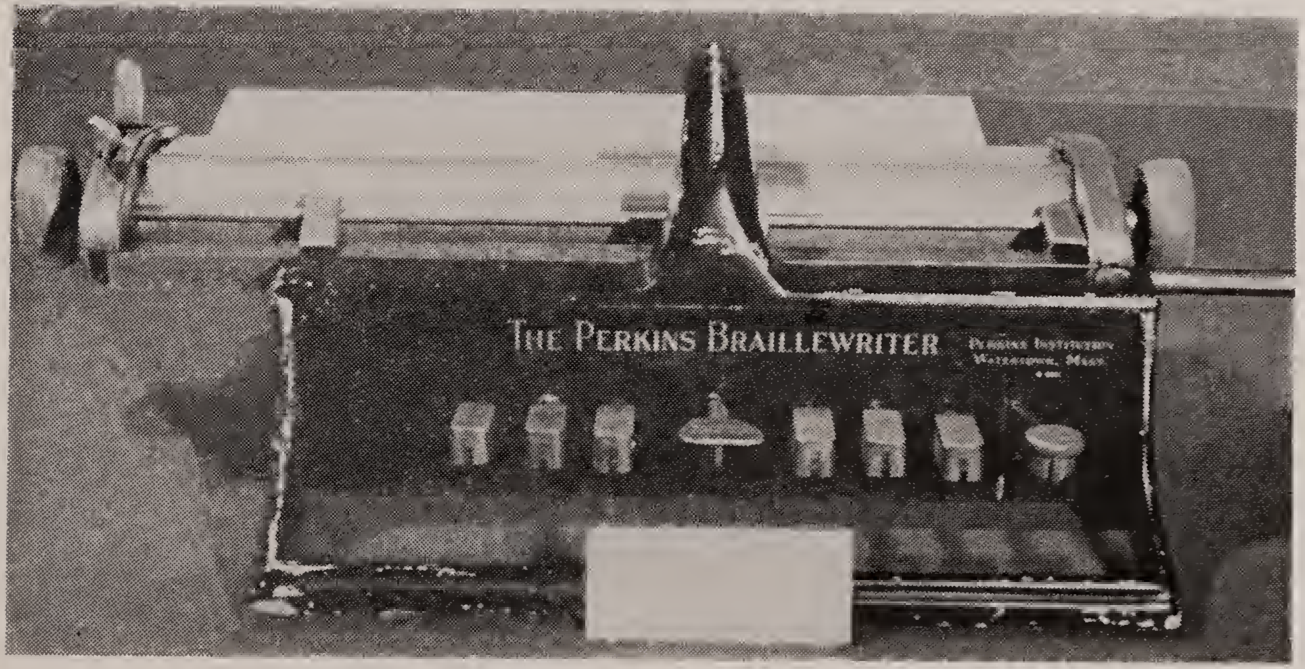

FIGURE 21 The Perkins Braillewriter, Model B

while it is still secured in the paper clamp. In this manner a new set of pins is used (as visible) which shifts the back side of the paper.

When fully extended the paper bed requires 20 inches of working space. The keys are mounted on both sides of the writer, with the long space bar in the middle. This offers free passage for the paper as it advances. This writer has no paper feed rollers; the only movement is that of the carriage which moves from left to right.

Figure 21 was introduced in 1920 and contained the following changes from earlier models:

1. A line spacing lever, in addition to the movement afforded by the paper feed knobs.
2. A back spacing lever.
3. The cell spacer key replaced the full length keyboard lever; and
4. Margin stops were included.

Eleven-inch paper is used.

This machine is considerably lighter than its predecessors, for the frame is made of cast aluminum.

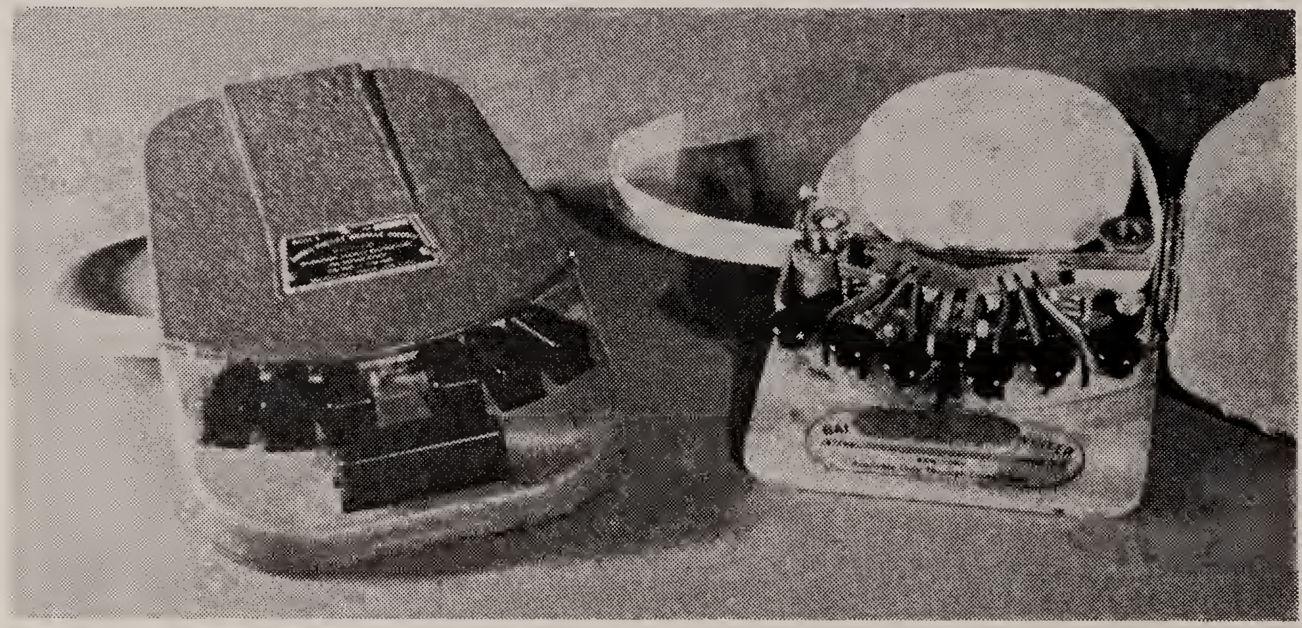

Figure 22 The Banks Pocket Writer

Figure 22 was invented by Dr. Alfred Banks of San Diego, California. The unit was produced by the International Business Machines Corporation and was made available through the Lions Club. It first appeared about 35 years ago. The machine weighs about 1½ pounds.

The tape used in these writers is ½ inch wide, and the whole machine measures 4½ inches in width and 7 inches in length—truly a "pocket" writer.

The writer has undergone various changes over the years. The present model is Number 6 in the series.

Figure 23 was produced about 35 years ago. It weighs 7 pounds.

A standard $\frac{15}{16}$-inch wide tape is used. The keys are made of wood and the housing of formed aluminum. The main difference between this model and the Stainsby writer of 1910 is in the absence of an external paper

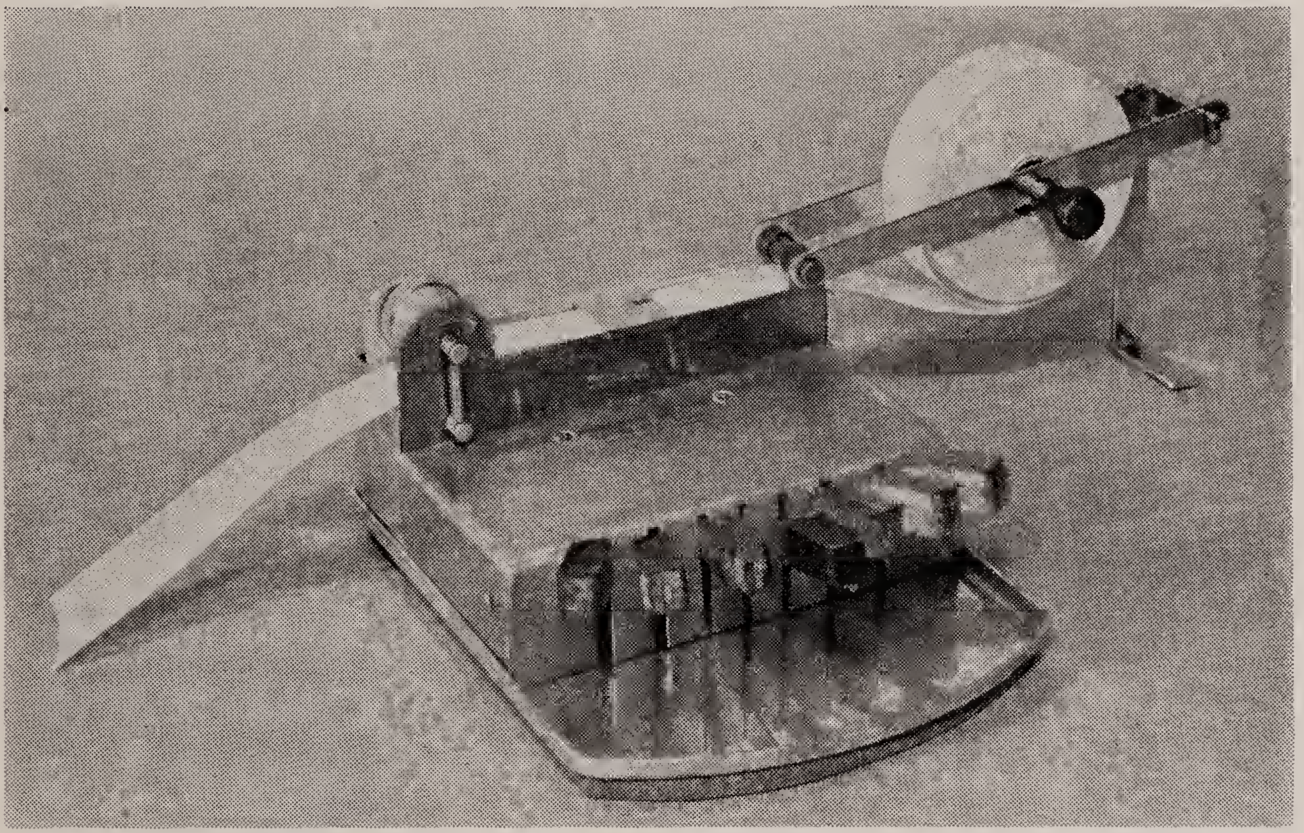

Figure 23 The Perkins Shorthand Writer

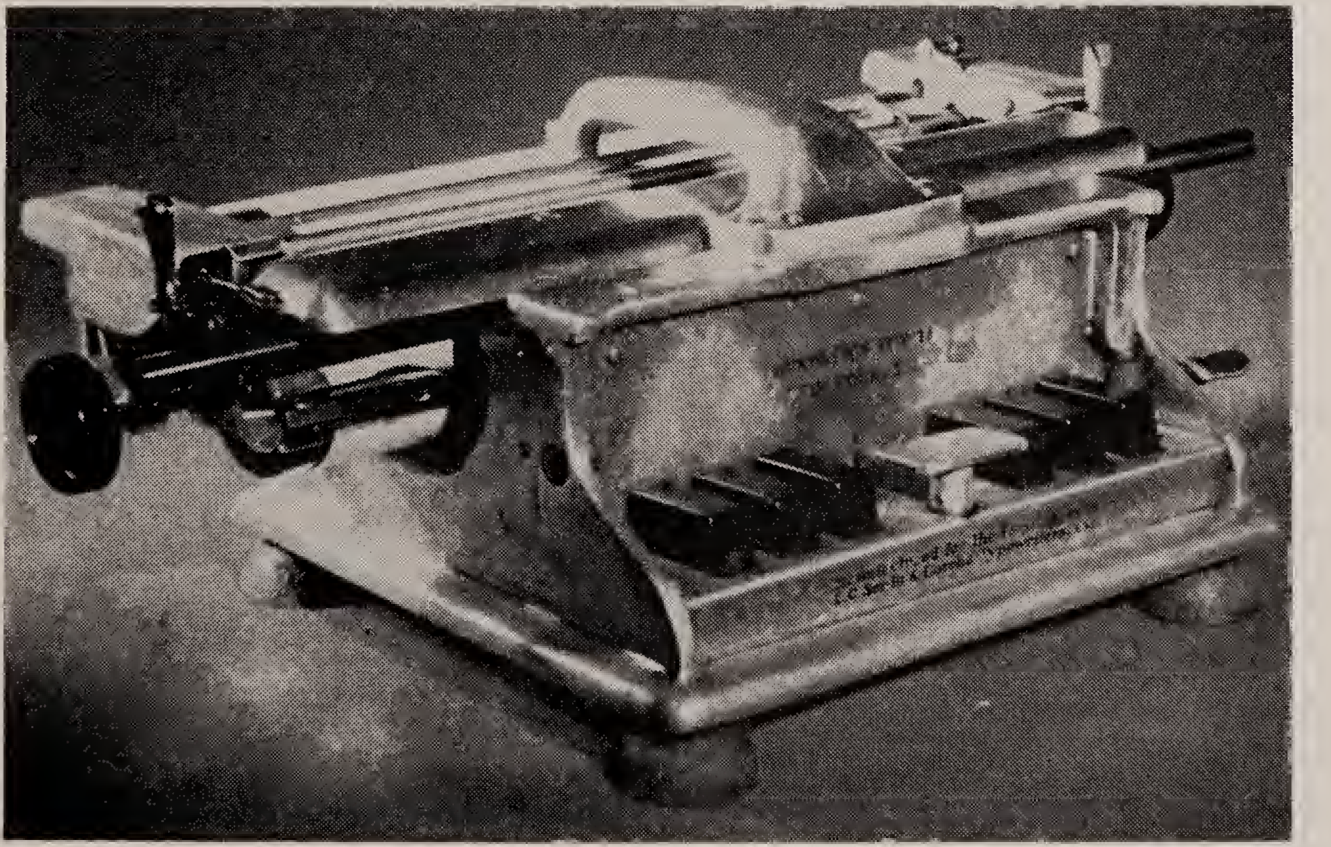

Figure 24 The "Foundation Writer"

feeding mechanism. On this model it is self-contained, thereby reducing the over-all outline and the size of the writer.

The photograph shows one of the several models produced.

Figure 24 was manufactured by the L. C. Smith Typewriter Company from 1933 to 1947 for the American Foundation for the Blind. Approximately 2500 writers were produced. Replacement parts are still available.

The machine weighs 15 pounds.

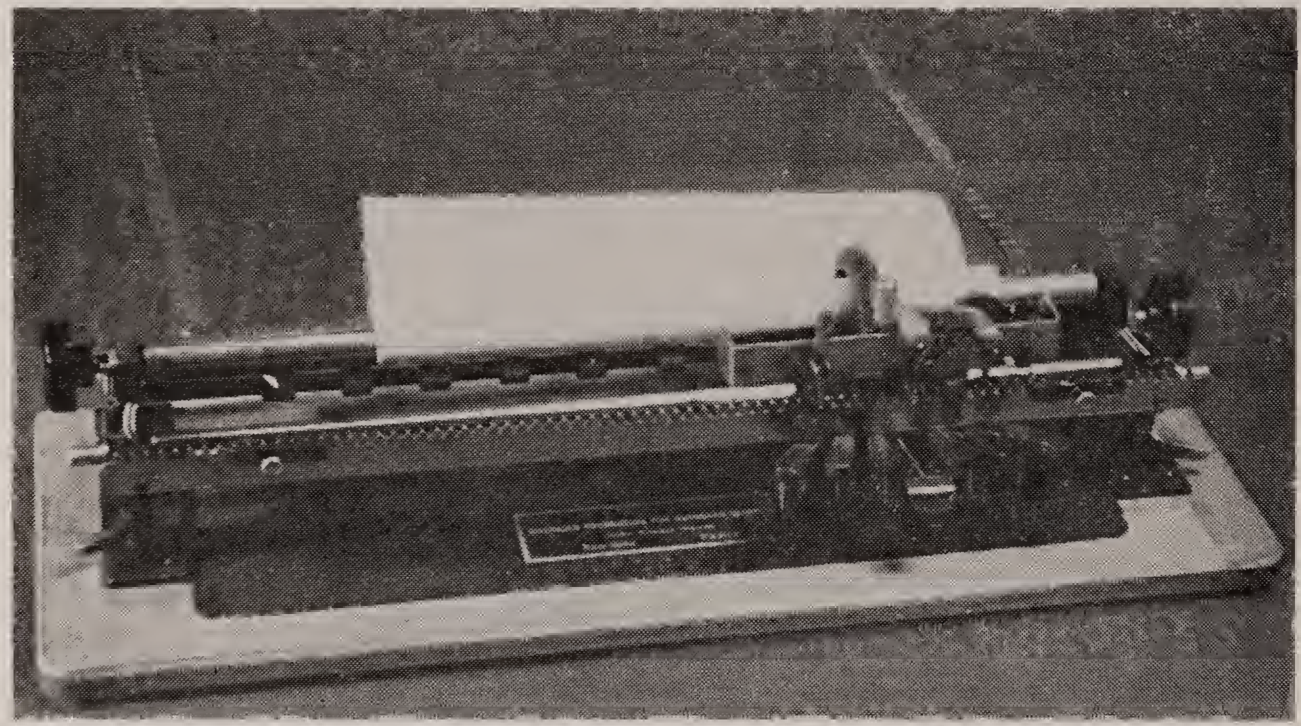

FIGURE 25a The Jauny Braillewriter

The Jauny writer was made for the American Foundation for the Overseas Blind. The base of the writer is 21 inches long and 8 inches wide; it is made of wood. The machine weighs 10 pounds (Figure 25a).

The unusual length of the carriage permits the use of 14-inch wide paper. (This is 2½ inches wider than American models.) The knob on the left side of the machine controls only the storage of the paper. The paper is wound around the ¾-inch solid steel rod. The knob on the right side of the machine controls the advance of the paper for individual line spacing, and functions independently of the paper storage knob.

An interesting feature of this writer is that the carriage is completely self-contained, including keys, stylus assembly, embossing die, and bell (see Figure 25b).

Figure 26a was produced by the Braille Institute of America in 1949, but is no longer in production (the cost was approximately $96). The machine weighs about 13 pounds.

The paper used is 12 inches wide and remains on the flat-bed during brailling. The carrying case is an integral part of the writer, serving as its

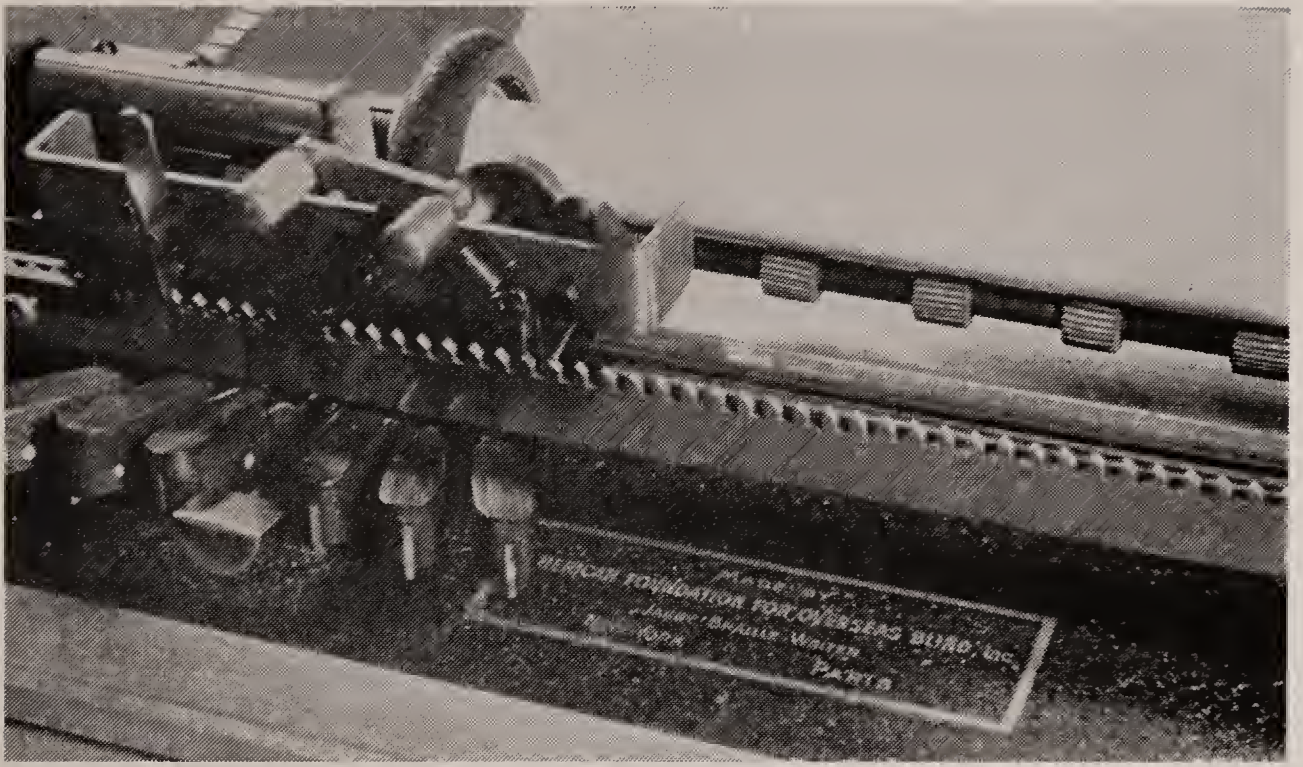

FIGURE 25b The Jauny Braillewriter, (Showing Self-Contained Carriage)

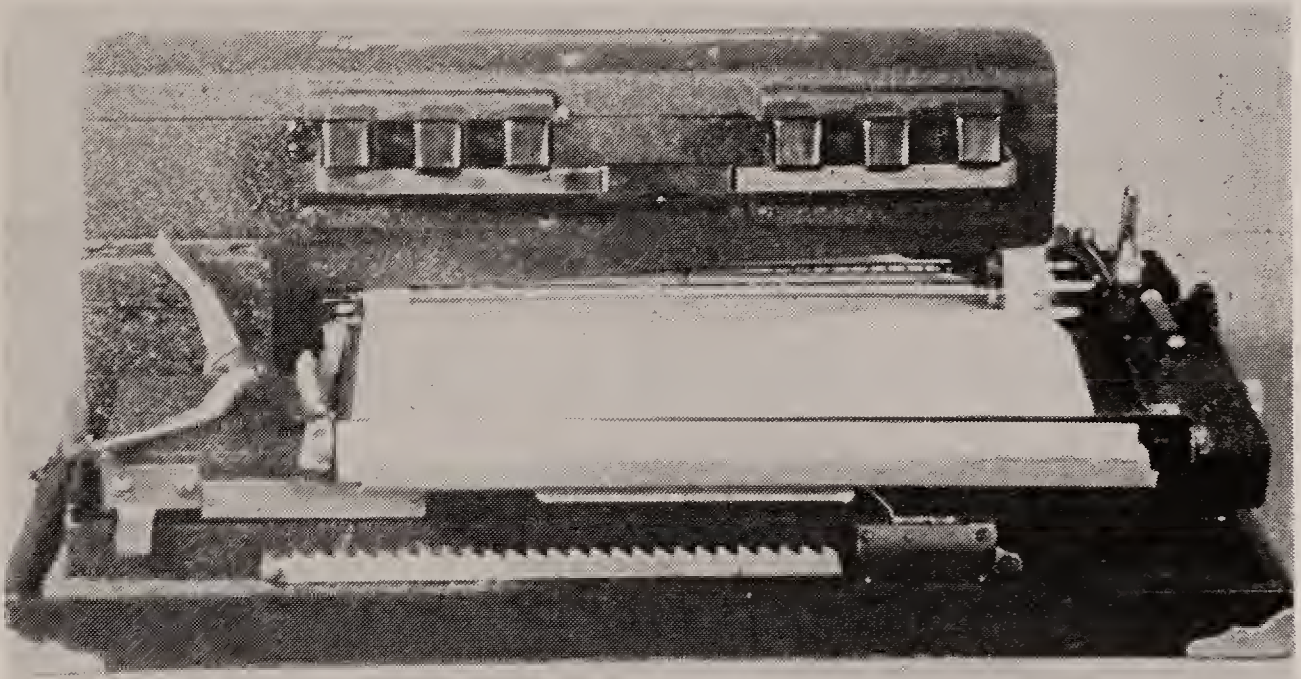

FIGURE 26a The Atkinson Portable Braillewriter

base. The keyboard location is a radical departure from the conventional design viewed in this survey. The carriage moves from right to left. All of the standard features are embodied.

To operate the writer 24 inches of table space is needed to allow for the extension of the carriage when in position to start a new line (see Figure 26b).

The New Hall writer is currently produced by the American Printing House in Louisville, Kentucky. It weighs 11 pounds (Figure 27).

The machine has a conventional keyboard with back spacing lever on the right side of the base.

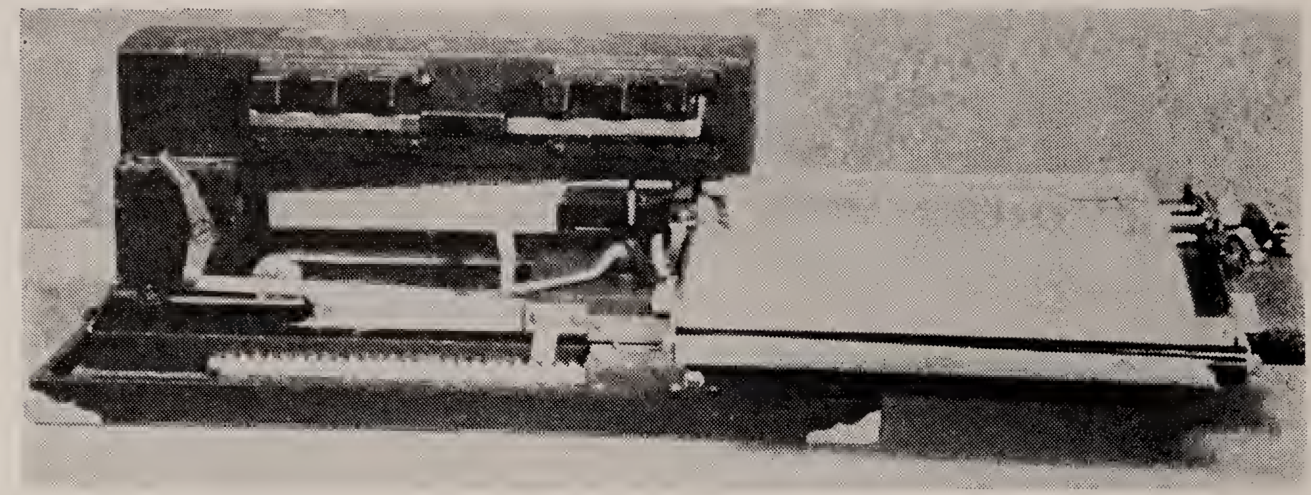

FIGURE 26b The Atkinson Braillewriter (Extended)

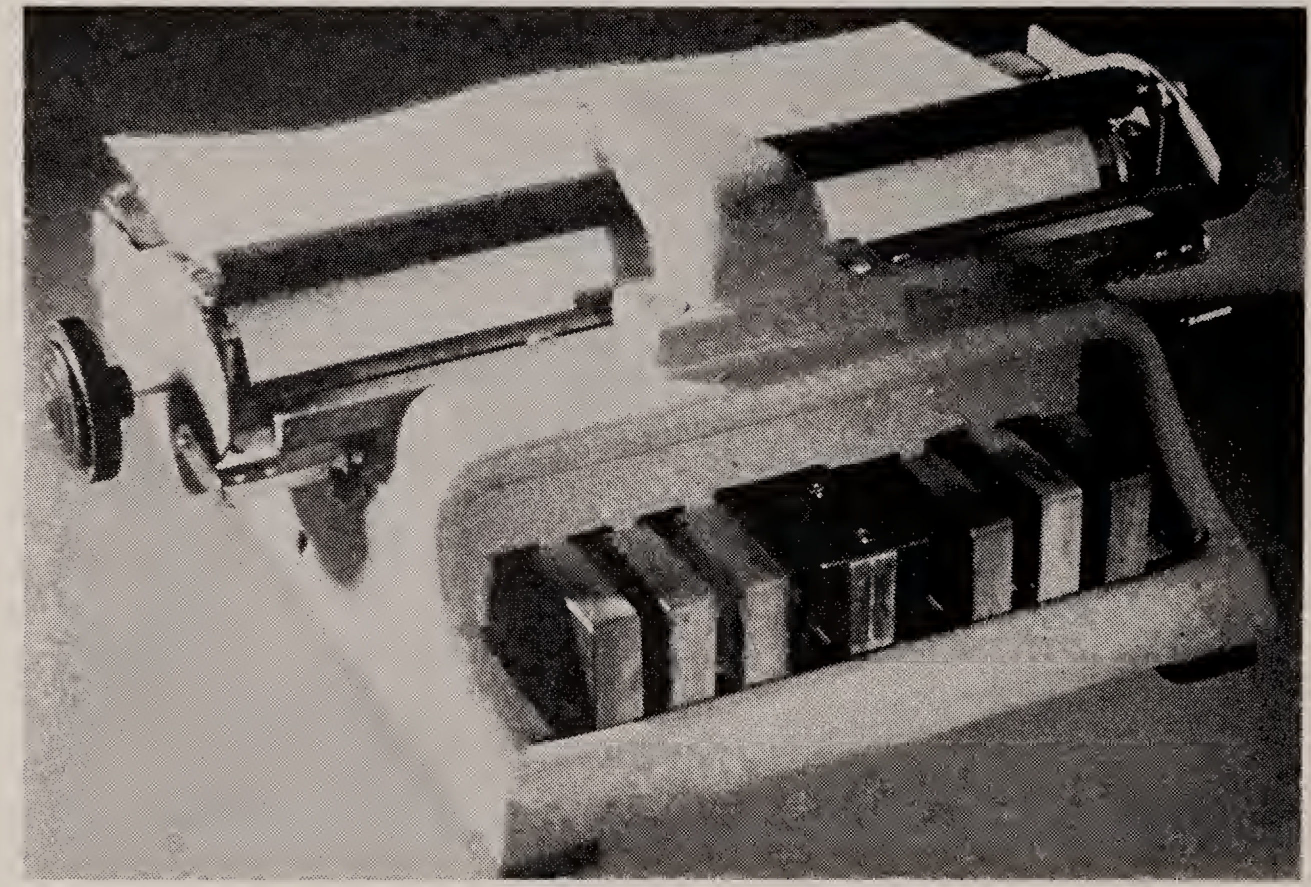

FIGURE 27 The New Hall Writer

Figure 28 is available from the Royal National Institute for the Blind in London, England. It is enclosed in a carrying case 7 inches square and 12 inches long. The selling price of the machine is approximately $65. The tape used is $\frac{15}{16}$ of an inch wide.

This writer is truly "silent" as compared with braillewriters in general, and American-made typewriters in particular.

The Andersson and Sorensen braillewriter is produced in Copenhagen, Denmark (American distributor: The Beutler Company, 457 West Broadway, New York 12, New York). It weighs 7$\frac{1}{4}$ pounds. The standard 11$\frac{1}{2}$ inch wide paper can be used (see Figure 29).

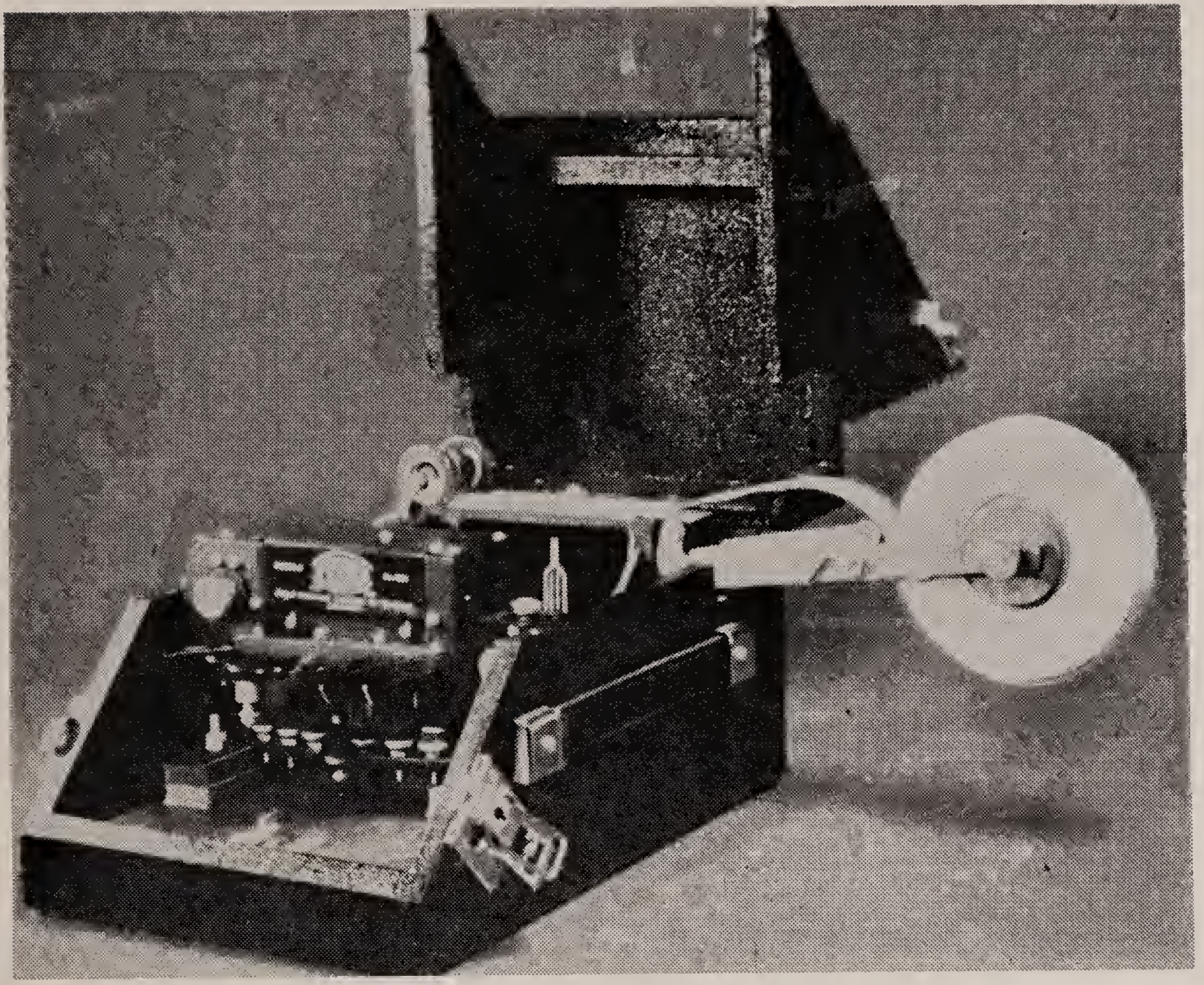

FIGURE 28 The Stainsby Shorthand Writer, Model G

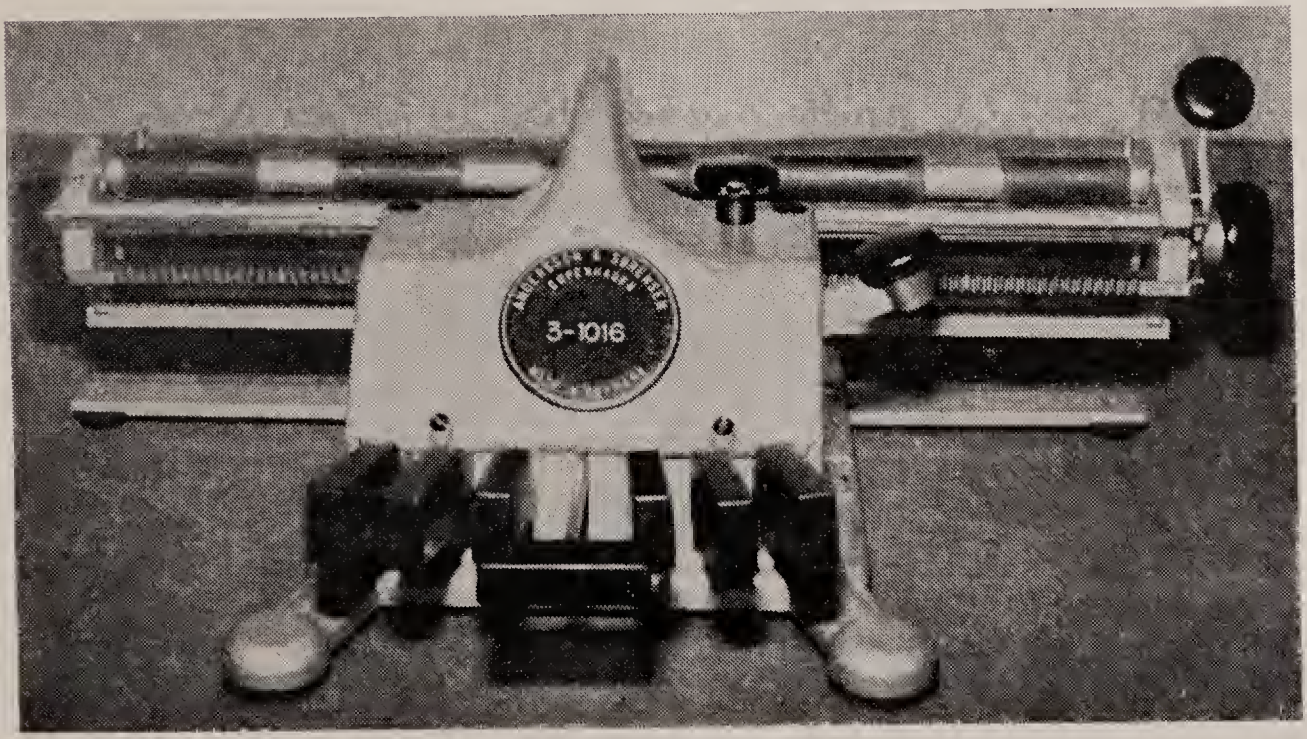

FIGURE 29 The Andersson and Sorensen Writer

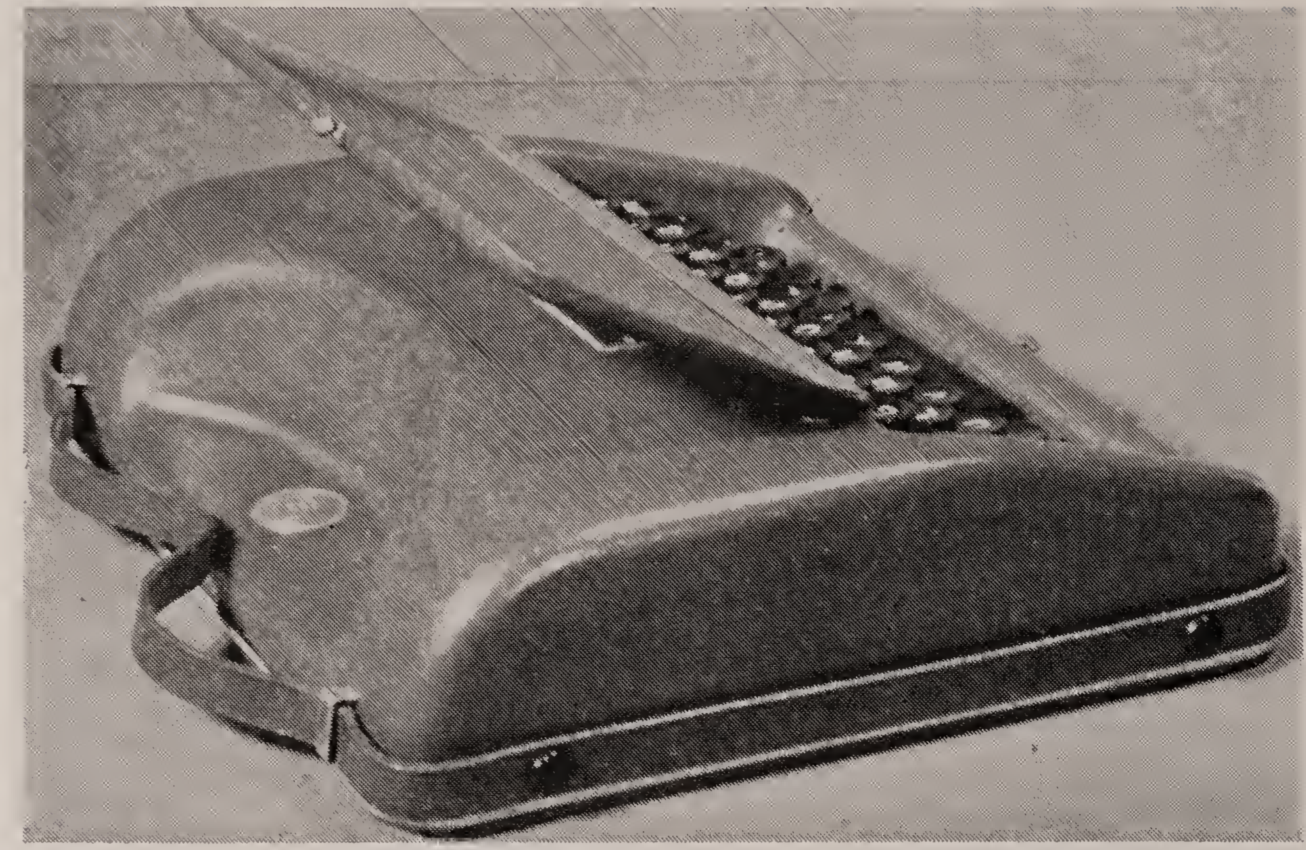

FIGURE 30 The Tellatouch Machine

Tellatouch is a device which provides a simple means of communication between a sighted (or blind) person and a deaf-blind person who can read braille. No training or special skill is required to operate this device. Tellatouch resembles a small portable typewriter in appearance. It weighs $3\frac{1}{2}$ pounds, and is 9 inches square by $2\frac{1}{2}$ inches high (Figure 30).

The keyboard is composed of three rows of keys, with ten keys each, as follows: first row, A to J; second row, K to S; third row, T to Z, plus punctuation marks. The fourth row is the standard braille keyboard.

At the rear of the machine is the round metal plate with the braille cell in the center.

The operator communicates with the deaf-blind person whose finger rests on the braille cell by striking the letter key of the alphabet, producing the proper letters of the word he wants to convey. As each key is depressed, the braille equivalent is raised in the cell under the reader's finger. At the end of each word, the spacer bar is depressed; this raises dot 3 (the code key for a space). Grade 1 braille is used.

The device is available from the American Foundation for the Blind.

A braille-to-braille communication device for the deaf-blind was made in Budapest, Hungary, about 1920. It weighs about 8 ounces. The operator communicates by using the six braille-producing keys; the braille reading cell is at the upper part of the writer (Figure 31).

See Figure 32 for an interesting size comparison between the Tellatouch and the Hungarian machines.

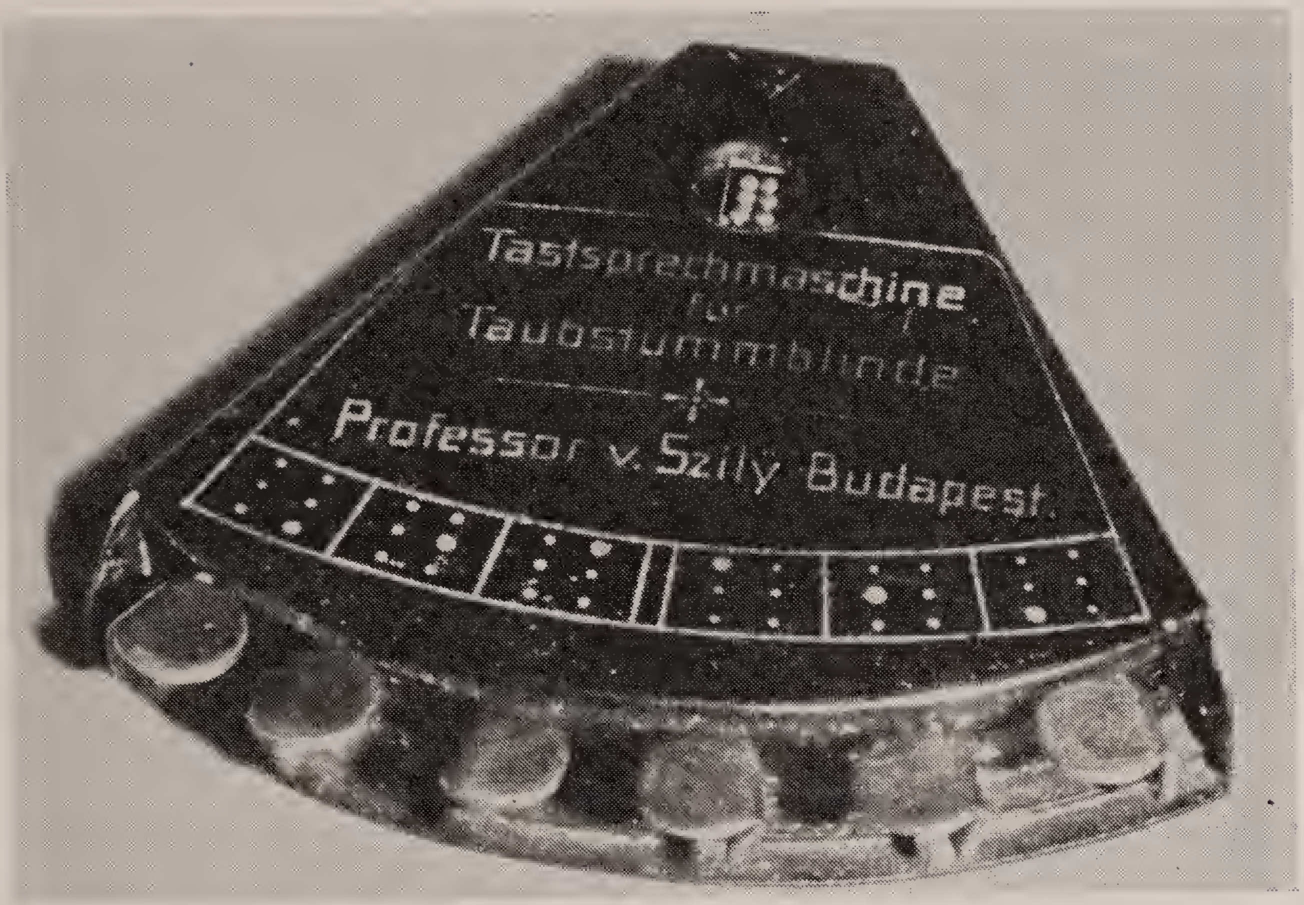

FIGURE 31 The Touch-Speech Machine (Tastsprechmaschine) for the Deaf-Blind

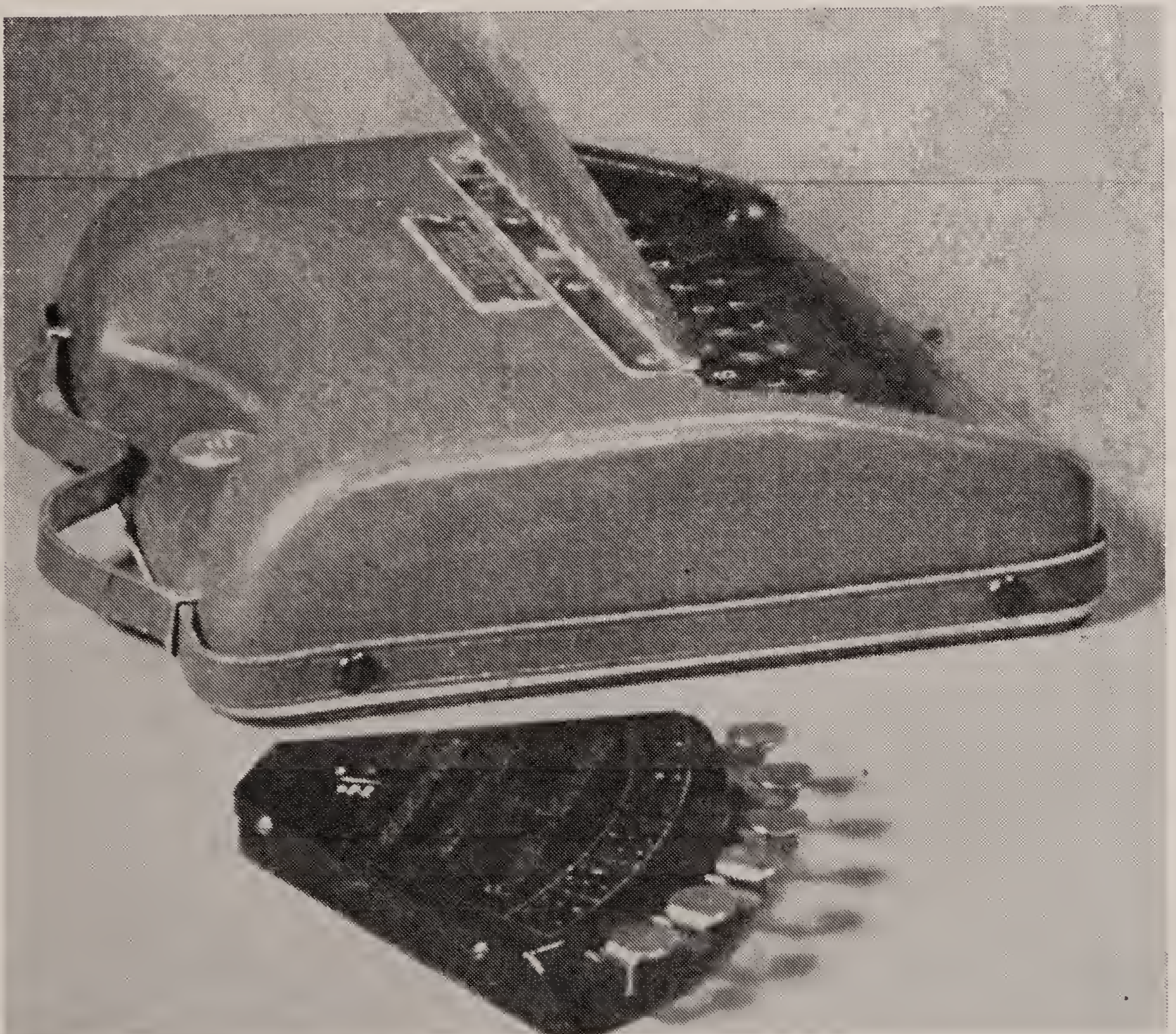

FIGURE 32 Size Comparison of Two Deaf-Blind Communication Devices

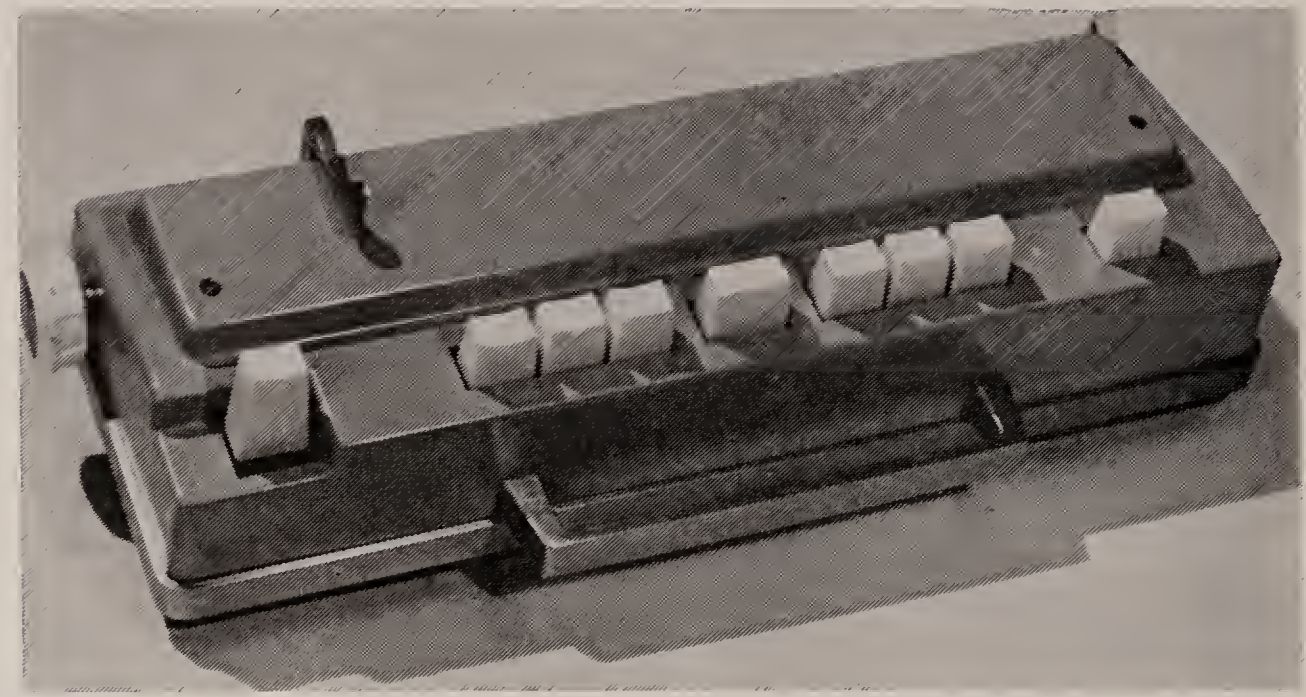

FIGURE 33 The Lavender Braillewriter

The Lavender braillewriter is produced by the American Printing House in Louisville, Kentucky. The Lavender writer embosses 40 cells of braille on paper 11½ inches wide. The paper is not wrapped tightly around a roller, but instead is allowed to exit through an opening in the cover in a fashion somewhat similar to a conventional typewriter. Paper of any length may be used including a continuous roll. The machine weighs 9 pounds, 10 ounces, and measures only 16½ inches long by 5¾ inches wide by 5 inches high. The case is made of Cycolac, a high impact resistant plastic; the dust cover, which snaps on to the case, is made of the same material (Figure 33).

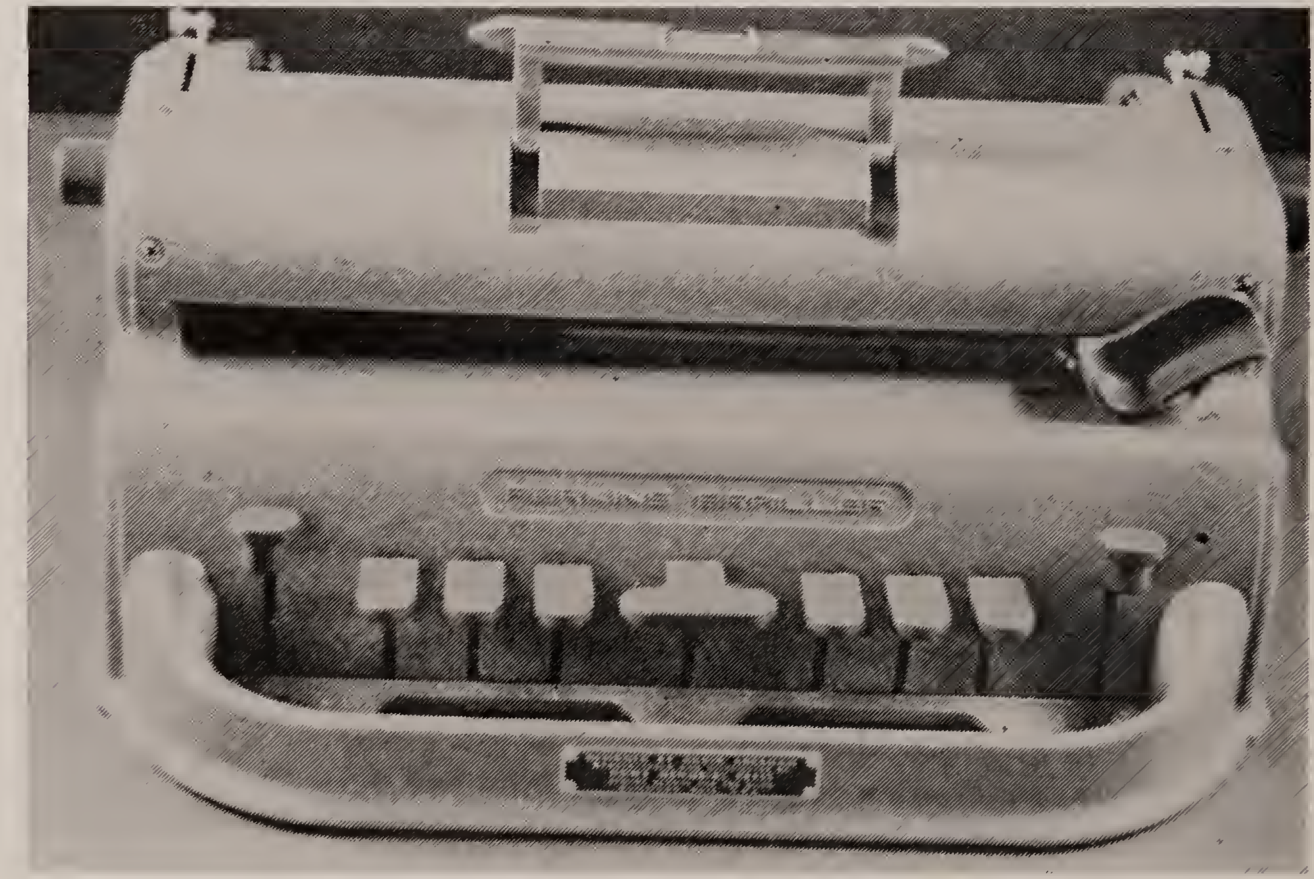

FIGURE 34a The Perkins Braillewriter

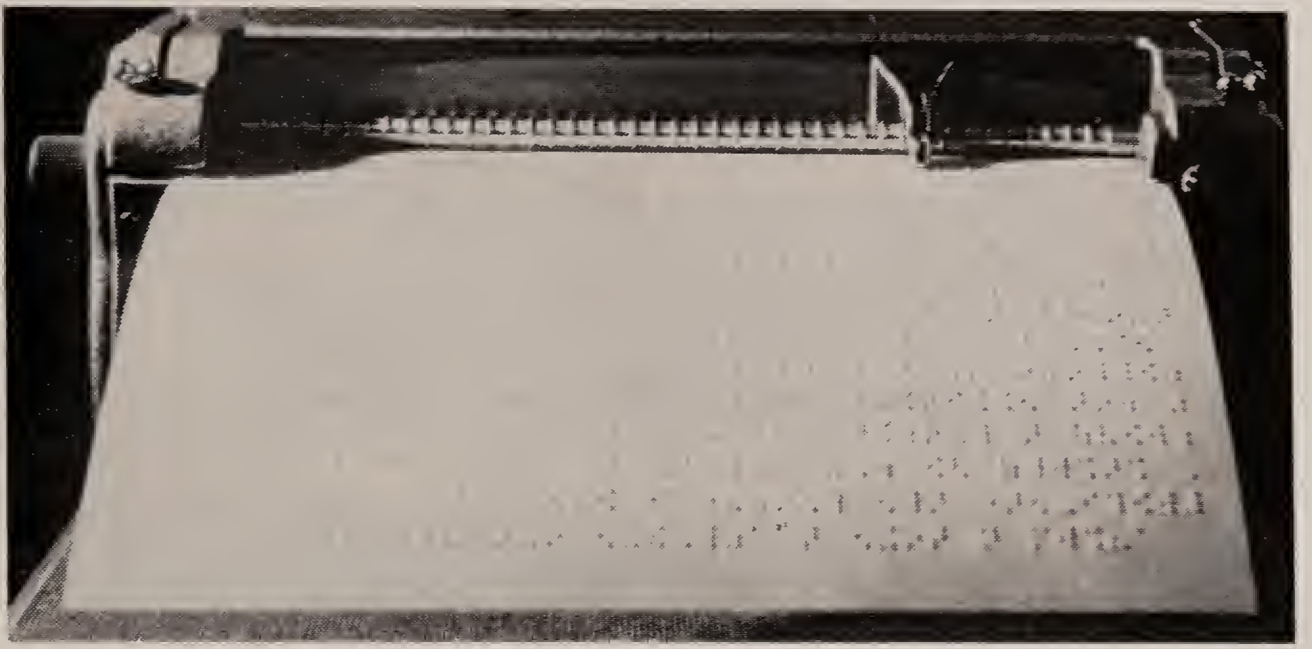

FIGURE 34b The Perkins Brailler: Stylus on Carriage

The Perkins Brailler was designed and developed in 1951 by David Abraham of the Howe Press of the Perkins School for the Blind. More than 20,000 Perkins braillers are in use throughout the world. Its accuracy and reliability are evidenced by the worldwide demand for the machine.

The principal change that has been made in the most modern Perkins brailler is that the carriage carries the styli rather than the paper. Incidentally, this is the same concept incorporated in the new electric typewriters (see Figures 34a and 34b).

The Perkins unimanual brailler is a special model of the Perkins brailler designed primarily for persons limited by disability to the use of one hand.

Perkins braillers are now available for immediate shipment.

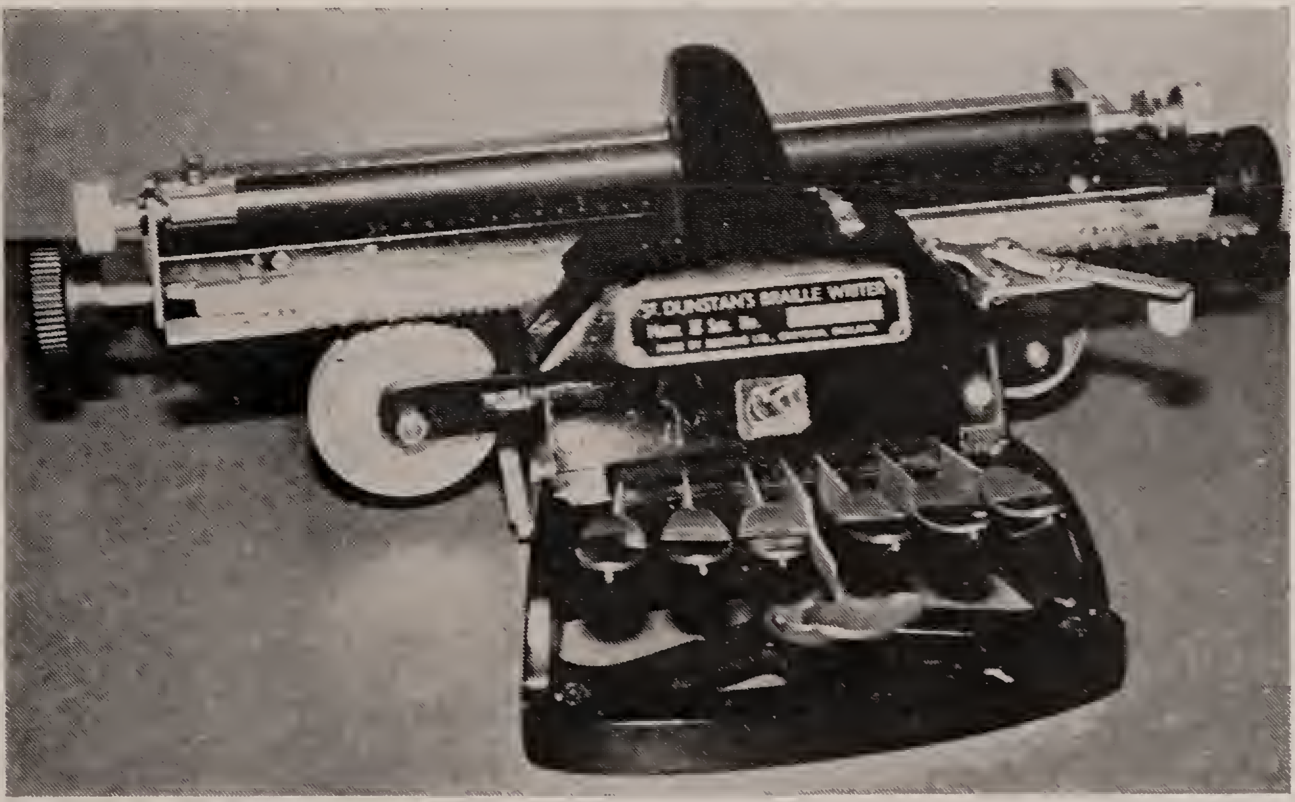

FIGURE 35 The St. Dunstan's Braillewriter

Information describing all of the features of the Perkins brailler, and other appliances produced at the Howe Press, is available in both inkprint and braille. Address the Howe Press of Perkins School for the Blind, Watertown 72, Massachusetts.

APPENDIX

Figure 35 was manufactured in Croyden, England, by Redwing, Ltd. (date unknown).

This braille writing machine has many of the features found in our modern writers. Among these are the following:

1. The backspacing lever is located at the right-hand side of the machine's strong die cast frame.
2. On the left is a small lever which allows for speedy return of the carriage to the left, and also disengages the pawl mechanism for free maneuvering of the carriage in either direction.
3. An arrow is secured to the top-right side of the casting, and a metal strip with braille numbers on the carriage. This device indicates the carriage position in braille cells 1 through 40.
4. Line spacing is accomplished by turning the paper feed knobs manually.
5. The paper is fed from the back of the machine into a clamp arrangement (part of the large roller on which the paper rolls around). The small rubber roller provides the friction necessary to keep the paper rolled smoothly around the large roller.

The weight of the machine is 9 pounds.

MATHEMATICAL AIDS FOR TEACHING BLIND CHILDREN

ROBERT E. BRUCE
The Virginia School for the Blind, Staunton, Virginia

Mathematical aids consist of those materials that will develop insights and skills which assure a real understanding of numbers. Mathematical concepts are visualized more readily and developed by use of these aids.

1. The American Printing House for the Blind (APH) has developed the Cubarithm or Arabic Numeral Arithmetic Type Slate. This device consists of a plastic type frame and either plastic braille cubarithm cubes or 24-point plastic Gothic numeral type. There are 256 square cells in a 16-inch by 16-inch frame. There is a tray at one end for holding the type when the frame is in use. The braille cubarithm cubes contain the braille digits 0 through 9 on five of the faces when properly placed with one blank side which can be used for various other purposes. The 24-point Gothic Arabic numeral cubes also contain the digits 0 through 9. The cubes are used to represent arithmetic equations. The Arabic numeral cubes are useful as well for teaching the shape of print numerals to our blind children.

2. The Brannan Cubarithm Slate is rigid plastic, and like the APH Cubarithm Slate has 256 cells in a 16-inch by 16-inch frame. The cells and cubes are larger, however. An additional feature of the Brannan cubes is that the letter "o" is on the sixth side of the cube and can be used for various purposes according to position. The main purpose of this slate is to aid in the teaching and working of problems of long division and the multiplication of large numbers. It can also be used for addition and subtraction, as with the APH slate.

3. The Taylor Arithmetic Slate is made of aluminum and contains 432 octagonal cells. It has a tray at one end for holding the type. The set of type consists of 225 pieces molded from plastic or lead. At one end of each piece of type are two braille dots placed along one side, at the other end a solid raised bar along one side. By placing the type in the holes according to a pattern, the digits 0 through 9, and the mathematical signs of operation, decimal point, and equal sign are represented. The bar is used

to show the digits from 1 through 8; the two braille dots are used to show the digits 9 and 0 and the remaining signs.

4. Texas Arithmetic Slate and Type. This mathematical aid is made of wood and contains 600 cells in a 20-inch by 30-inch frame. The type is Philadelphia Great Primer print showing the digits 0 through 9. Its main purpose is to represent all arithmetic equations involving the four operations. Since the numerals are Arabic digits, the type can be used in teaching the shape of print numerals to blind children.

5. A clockface with braille notation is designed for teaching blind children to tell time. It is made of metal and has movable hands geared in the regular manner. There is no motor or other driving device. The twelve numerals for the hours are embossed in both braille and print. Again, the print numerals can be used to show the shape of these figures. Because of the gear mechanism, the hour hand follows the minute hand in the proper ratio as the latter is moved forward or backward. As companion aids there are sheets of blank circular clockfaces containing the numbers of hours in braille and without hands.

6. The Kine Mltply Vizr is an aid designed as an incentive to learning multiplication tables through 12. It is an 11-inch by 11-inch square made of thick cardboard. Mounted on this is a plastic wheel embossed with the numbers and fitted with fluted edges for manual turning and a gear mechanism to place the wheel for reading. A sheet of heavy paper placed over the wheel has a V-shaped hole cut out so that the braille numbers can be read for any table as the wheel is turned. The instructions state: "On the top sheet of paper (over the wheel) the numbers from 1 to 12 are written on either side of the V-shaped hole . . . , the odd numbers being on the left-hand side and the even numbers on the right-hand side. To use this device, say to find the Table of 8's, the wheel is turned until 8 comes into position . . . at the bottom left-hand corner of the V, with the multiplication sign (dots 1-6) at the bottom right-hand corner. To find the product of 8 and 9, first find the 9, second from the top of the left-hand column on the top yellow sheet and then read 72 immediately to its right on the . . . wheel in the slot."

7. IMOUT Game—Braille Edition. This aid was designed for drill in the quick recognition of fractions of equal value, e.g., $\frac{15}{20}$ equals $\frac{3}{4}$. There are 20 corrugated cards on which are five columns of fractions, five fractions to a column (in braille and in print). The five columns are headed with the letters of IMOUT and there are holes punched in the center of each fraction in which we insert pegs. A box of 150 cardboard squares, each

overprinted in both braille and large type with one of the letters of IMOUT plus a fraction, is furnished. When a square is taken from the box, the letter and fraction on it are called out. Each pupil reads down the column headed by the same letter to see if his card has the same fraction or its equivalent. If he finds it, he puts a peg in the correct hole. A player wins when he has five pegs in a row, horizontally, vertically, or diagonally.

8. The Graphic Aid for Mathematics is a cork board on the surface of which has been mounted a synthetic molded rubber mat embossed with graph lines $\frac{1}{2}$ inch apart. Included in the kit are headed pins, rubber bands, and three flat spring wires. The spring wires are used to construct circles and arcs; the pins and rubber bands are used to construct lines. We can also construct circle and bar graphs.

9. Mitchell Wire Forms with Matched Planes and Volumes is a set that consists of geometric figures showing outline forms, planes, and solids usually found in geometric problems. Since the respective figures in all three forms have been made to the same scale, the wire frames will fit over planes and solids of the same shape.

10. The Brown Slate, although a writing device, is especially good for working mathematics on braille paper. The slate has four lines of 28 cells each and has an added frame on top to hold the pins for mounting paper so that it is possible to drop open the back of the slate and read what has been written without taking the paper out of the slate.

11. The Hoff Aid is an upward-writing slate and is used in making mathematical calculations on paper. Each line consists of 30 cells and the writer uses a regular stylus to punch down over the raised dots, with the paper in between so that the dots appear as written with any brailler. The paper is fastened in a hinge and placed between the bottom of the sheet and the die-box. This hinge is movable up or down at will and the die-box is movable cell by cell to the left or right at will. As many as 16 braille lines can be written.

12. Graph Sheets are also available; each sheet is 9 inches by 12 inches with 16 squares and each square measures $\frac{1}{2}$ inch. The graph squares are embossed on braille paper.

Each of the above 12 items is distributed by the American Printing House for the Blind, Louisville, Kentucky.

13. IMA WHIZ is a mathematical bingo game consisting of 24 cards carrying 6 multiplication problems and 6 division problems. Another set consists of cards for addition and for subtraction. Each set is available in braille and in large type. The cards are shuffled and the numbers called off

one by one. When the number is the answer to a problem on a player's card, he makes a note of it and the first one to have all his problems answered, wins.

14. Draftsman's Compass is made of die-cast aluminum with a ball point pen tip. It is to be used with the Raised Line Drawing Kit. The regular size has 4-inch arms but it is possible to secure extra tips to make the instrument into 8-inch dividers. There is a screw adjustment to open or close the instrument.

15. Graph Marking Slate is for use with the Raised Line Drawing Kit. It has 24 cells and can be used as a single line only. A hollow stylus permits the writing of upright braille. This slate may also be used as a scale and a straight edge.

16. The Raised Line Drawing Kit contains a rubber covered board with clips to hold a sheet of polyester film. To draw on the film we use a ball point pen filled with a colorless lubricant. Lines so drawn can be felt on the top surface of the film. It is not necessary to turn over the page to feel the lines as is required with tracing wheels.

17. The Protractor is transparent, semicircular with 3-inch radius and a $6\frac{1}{2}$-inch pointer. To read the protractor, there are single braille dots at each 5 degrees, double dots at each 10, and triple dots at 45, 90, and 135 degrees. It is not designed for close measurement.

18. The Slide Rule is of the circular type and consists of a logarithm "C" scale around the outer edge with large embossed Arabic and braille numerals and a set of pointers, two on the face and one on the back. Pointer "A" is set on 1 and pointer "B" on the multiplicand and then both are locked together. Pointer "A" is moved to the multiplier and the product read at pointer "B." The pointer on the back side is rigidly affixed to pointer "A," and when "A" is set on a number the square root can be read on a linear scale.

19. The French Cubarithm Slate is similar to the APH slates with braille symbols on five faces but this set of cubes has a raised line on the sixth face. Another feature of the cube is that dot one is offset so that the surface can provide three arbitrary signs. Dots one and two are also offset to provide two more arbitrary symbols. With appropriate positioning, the raised line will provide four more arbitrary symbols.

20. The British Taylor Slate comes in two models, the large slate for arithmetic, and another which uses algebra type. It is used like the type slate mentioned in No. 3 above.

21. There are three braille rules available for use in measurements—the

foot rule, the two-foot rule, and the yardstick. The aids have one dot embossed on the metal for $\frac{1}{4}$- and $\frac{3}{4}$-inch marks, two dots for the $\frac{1}{2}$-inch mark and three dots for the 1-inch mark. Below these dots are the embossed braille symbols 1 through 11 on the foot ruler, 1 through 23 for the two-foot rule, and 1 through 35 for the yardstick.

22. A Protractor, metal, semicircular, of 3-inch radius, bears single dots at 15, 75, 105, and 165 degrees, double dots at 30, 60, 120, and 150 degrees, and triple dots at 45, 90, and 135 degrees. Notches are cut in the circumference every 5 degrees from the 5-degree mark through the 175-degree mark.

23. A drawing compass for use with the polyester film on a Raised Line Drawing Board consists of a ratchet wheel on one arm and a sharp point on the other. A screw adjustment permits the arms to be set at various radii from $\frac{1}{4}$ inch to 6 inches.

24. A Line Drawing Instrument consists of a ratchet wheel attached to a flat metal handle. About 1 inch above the ratchet wheel is a rod, 1 inch long, perpendicular to the flat handle, to be used as a rest. The flat handle is placed against a rule when drawing a line.

Items 13 through 20 are available through the American Foundation for the Blind, Inc., New York, N. Y. and items 14 through 24 are available from the Howe Press, Perkins School for the Blind, Watertown, Massachusetts.

25. Braille Mathematical Chart Copyright 1955 by E. J. George, distributed by Sun Oil Company, Philadelphia, Pa. (Hess and Young, Embossers.)

"This type of mathematical chart for multiplication and division was developed first for sighted people as a new approach to already known facts.

"The idea occurred to the inventor that this new approach could also be used for the blind. The multiplication and division chart is made up of a log grid superimposed diagonally upon a log log grid. Besides being a practical device for computation, the chart is intended as an educational tool to illustrate a method.

"Charts using this same basic grid have been prepared to perform square and square roots, cube and cube roots, and logarithms.

"The chart is made up of solid vertical and horizontal lines having the same dimensions, and diagonal lines having different distinguishing dimensions. The spacing between the lines is logarithmic, with one set of spacings for vertical and one set for horizontal lines, and two sets for diagonal lines.

"The braille scales at the top and bottom outside borders of the chart are read horizontally as usual. The scales at the left and right outside borders are read by turning the chart clockwise so as to allow normal reading. For convenience, the number 10 on the chart will be represented by an upper case number O. Some interpolation is also required in using the chart."

26. The Judy Math Boards, of which there are four, are the Data Graphing Board, the Equation Board, the Geometric Relation Board and the Circle Board. These are 23 by 23 peg boards, with 1-inch spacing of the $\frac{3}{16}$-inch holes. The Data Graphing Board is usable for histograms, bar graphs, line graphs, etc. The Equation Board, set up for the four quadrants, is used for linear equations, quadratic equations, systems of equations, etc. The Geometric Relation Board consists of two 6-inch circular protractors and is used for showing angles, parallel lines, triangles, polygons, and vectors. The Circle Board, as its name implies, is used for demonstrating the circle, arcs, chords, inscribed polygons, and trigonometric functions.

27. The Calculaid, the most recently developed aid, was invented by Dr. Andrew F. Schott in 1961. It consists of wheels rigidly fixed in a yoke but which can be rotated. The braille symbols for numbers 0 through 9 are embossed on the wheel faces. There is a stop so that the wheel cannot be rotated backward beyond 0 nor forward beyond 9. The Calculaid has ten rows of wheels in five columns. At the left is a wheel containing the addition, subtraction, and multiplication signs. Between each row are five separation signs—braille dots two and five. To the far left is a movable division sign permitting this sign to be placed between the divisor and the dividend. Since the wheels are fixed, there is no chance of losing cubes and if the aid falls, there is no displacement of the wheels already set up. Above the first row, there is a sliding decimal point to allow the working of problems in decimals and in dollars and cents. In the square area above the Calculaid, there is a frame to hold a Numberaid or abacus of special design used for teaching the operations with numbers.

28. The Numberaid itself is over ten years old. It was also redesigned for use by the blind by inserting a spring inside the counters. This spring keeps the counters in the position placed even if the aid is stood upright. Dr. Schott, the inventor, calls this an "American Abacus" because it has nine counters below the stop bar and two counters above the stop. No counter pushed to the stop bar represents 0 and then the other digits up to 9 are represented by a counter. The device consists of five rods so numbers up to 99,999 can be placed on this abacus.

THE ABACUS AND ITS USE BY THE BLIND

TERRANCE V. CRANMER
State Bureau of Rehabilitation Services, Frankfort, Kentucky

Before undertaking a discussion of the use of the abacus by blind people it might be well to review in brief the history of this device and its use by sighted people.

In one form or another the abacus has been known to man for many thousands of years. Indeed the word "abacus" is derived from "abax," the Greek rendering of a Semitic word meaning "a table covered with sand or dust for the purpose of reckoning." The first abacus was just such a table covered with sand or dust, upon which primitive arithmetic calculations were made. In the course of time, the dust-covered table was replaced by the so-called ruled or lined abacus. This was a table upon which sections were ruled or marked off. In these sections, counters were placed to represent numbers. The positioning of the counters made calculation possible.

The ancient Romans made widespread use of the abacus. Their version was of the grooved type: a tablet into which deep grooves or channels were cut. Balls were used as counters, and they rolled back and forth along the channels.

Modern scholars believe that the abacus eventually found its way into the Orient through trade with ancient Rome. It is believed that about the sixteenth century the ruled and grooved abacus gave place to a type which more nearly resembles the rod abacus of present-day use; i.e., with a frame through which rods are anchored. The counters were represented by beads which traveled back and forth on the rods. This change made the abacus portable and more compact.

In the Orient, the abacus underwent many modifications over the centuries: the number of counters on each rod was reduced from 15 to 5; and improved methods of abacus calculation were developed by Chinese and Japanese mathematicians. The abacus has become so useful a part of oriental business life that 90 percent of all business calculations in Japan are done on the abacus. A Japanese who holds an abacus operator's license claims membership in a proud and honorable profession.

In recent years, numerous competitions have been held between licensed abacus operators and operators of electric calculators. Invariably the abacus operator is able to outperform the operator of the electric machines in both speed and in accuracy.

Although it has enjoyed continuous popularity in the Orient the abacus fell into disuse in Europe toward the end of the Dark Ages. No one can say with certainty why this happened. It may be that many things worked together to bring about its decline. Moorish mathmaticians are credited with having brought to Europe not only algebra but the Hindu-Arabic system of numerals. Hindu-Arabic numerals made written calculations simpler than the clumsy Roman numerals. Writing materials were becoming more plentiful and this, coupled with the fact that the abacus is not a recording device whose step-by-step calculations can be checked for accuracy, may have caused it to fall into disuse.

Trusting that this brief review of the history of the abacus will suffice, I would like to consider now one special application of this remarkable reckoning device: its use by blind people.

Since Nicholas Saunderson developed his arithmetic board in England in the seventeenth century, many mechanical aids have been contrived to assist blind persons in making calculations. It is interesting to note that in the almost three hundred years since Saunderson's time, there has been no successful adoption of the abacus as an aid for the blind.

Since 1956 my colleagues in the Kentucky Division of Services for the Blind and I have been conducting informal but serious tests into the possibility of modifying the Japanese abacus for use by blind people. In that year the American Association of Workers for the Blind met at Los Angeles. While there, I visited the Japanese section of the city. I became extremely interested in the abacus and bought several for experimental purposes. It was immediately apparent that a conventional abacus would have to undergo certain modifications before it could be used by a blind person. I have already referred to the amazing speed attainable by sighted operators of the abacus. This speed is possible in part because of the freedom with which the counters are able to move back and forth on their rods. A counter can be caused to move by the merest touch of a finger tip. Obviously a blind person then could not read the result of his calculation without destroying it. In the years that followed I made many modifications of the abaci bought in Los Angeles, and it was on these instruments that my colleagues and I learned the oriental principles of abacus arithmetic. Eventually the modified abaci gave way to those especially designed for a blind operator: spherical beads were used as counters, and adequate bead travel was allowed for easy reading.

With this specially designed abacus our skill increased and we were able to do complex arithmetic quickly, efficiently, and effortlessly. We could add, subtract, multiply, divide, extract roots, handle decimals, and do the arithmetic associated with fractions at speed never before attainable by blind people. More important, we could do these calculations mechanically and without the need for mental arithmetic. While I do not anticipate speeds comparable to the electric calculator, it seems certain that the blind, using this special device, could acquire speed and accuracy superior to that offered by braille, peg boards, and other aids.

I discussed our findings with authorities at the American Printing House for the Blind. The Printing House, in cooperation with the Division of Services for the Blind of the Library of Congress, is about to evaluate the "Cranmer Abacus for the Blind" through a program of field testing. A group of blind Kentuckians will be taught to use the abacus. After training, their ability to solve problems in arithmetic both with and without the abacus will be tested. If the research findings bear out our expectations, I hope that it will not be long before the abacus will be available to any blind person who wants one and that it will find its place in the education of blind children.

A word about the design of the abacus for those interested in technical information. The abacus is rectangular in shape. It measures $5\frac{5}{8}$ inches long by $3\frac{1}{8}$ inches wide and is approximately $\frac{1}{2}$ inch thick. Anchored to the plastic frame are 13 rods made of music wire. These rods travel the width of the frame and are $\frac{3}{8}$-inch apart. Running the length of the frame, there is a bar $\frac{3}{16}$ inch wide. This bar cuts across each rod or column. Upon each column, 5 beads are strung—4 of these beads are on one side of the bar while the fifth bead is on the other. The beads have a diameter of .275 inch.

Behind the 13 columns, sandwiched between them and the back of the abacus, is a pad of felt over foam rubber. It is this pad which offers the necessary resistance to bead travel and makes the abacus usable by a blind operator.

On the face of the lower member of the abacus frame, there is a dot at the end of each column. These help the operator to locate his place. At three-column intervals, a solid vertical line is placed between columns. This line serves as a decimal point, or it may be assigned the role of the comma as in written arithmetic.

In the time at my disposal it would be impossible to teach all the fundamentals of abacus calculation. I would like, however, to review one or two of the basic principles involved. Only one digit can occur on a single column at a given time. A two-digit number would require the use of two columns. A seven-digit number would require seven columns. The five beads or counters on a column can be used to represent the ten digits, 0 through 9. I spoke earlier of the bar which crosses each column and separates four beads from the fifth. When the beads are as close to the bar as possible they are active. That is, they take on their appropriate value. When they are as far away from the bar as possible they have either no value, or represent the digit 0. In the operating position four beads are below the bar and one is above the bar on each column.

The lone bead above the bar represents the digit 5. Each of the four beads below the bar has a value of 1. To indicate the number 1, we would move one lower bead up to the bar. If we move a second lower bead on this same column we would change the 1 to a 2. Move up one more lower bead, we will have 3, and moving the fourth lower bead on this column up to the bar will give us 4. If we want to add 1 to this 4, it is impossible to move up any more lower beads, so we shift our attention to the top of the column. With one downward sweep of the finger we move the upper bead down to the bar and clear away the four lower beads, moving them to the bottom of the column. Now the single upper bead is close to the bar while the four lower beads are away from it. This indicates the digit 5. We have added 1 to the 4 by entering the 5 and clearing away the 4 (which we had set previously). This is very much like adding one penny to four pennies by picking up a five-cent piece and clearing away four pennies. We can continue to add 1 to this column, thus representing the digits, 6, 7, 8, and 9. So we have seen that on a single column we can represent the digits from 0 to 9.

The abacus is far more than a simple device for recording and manipulating numbers. It offers a means for performing mechanically the four processes of arithmetic through the application of quite simple rules. These rules must first be committed to memory, and through practice they become automatic. Here is an example of the kind of rule that must be learned: To add the digit 8 to a column already containing a number, "cancel 2, set 1 left." This means to clear away two active counters from the column to which the 8 is to be added, and to move up one counter on the column immediately to the left; in simple arithmetic: add 10 and subtract 2. By committing these rules to memory, it is not necessary to go through a mental addition of a long series of digits, remembering the number to be set down and the number to be carried. In fact, complete familiarity with these rules frees the mind for more important tasks, and leaves the work to be done by the fingers alone. There are 17 rules for addition and 17 counter parts for subtraction. A few weeks of daily practice permits the unthought-out application of these rules, and the operation of the abacus becomes very much like touch typing.

Unlike written arithmetic, in which calculation is done from right to left, abacus calculation is done in a left-to-right direction. This eliminates the necessity for number reversing and makes for increased speed and efficiency.

In the early development of our abacus my associates and I learned the principles of calculation from a book entitled, *The Japanese Abacus: Its Use and Theory,* by Takashi Kojima. (The book is published by the Charles E. Tuttle Company of Rutland, Vermont.) Later we developed certain techniques and teaching concepts which seem particularly suited to blind people. These concepts and techniques, and a detailed treatment of the principles of abacus calculation, are contained in the instruction book, *Using The Cranmer Abacus For The Blind,* by Fred L. Gissoni. This has been prepared as a training manual for the students in our abacus program, and is published by the American Printing House for the Blind in Louisville, Kentucky.

I would like to state as emphatically as I know how that I am not a mathematician. My interest in arithmetic is casual, and my needs are ordinary. Nevertheless, as a blind person with an ordinary need for arithmetic, I have a keen appreciation of the potential of the abacus as an aid to blind people. To scientists and technicians it could be of great value by enabling them to handle extremely difficult calculations quickly and with complete accuracy. To vending stand operators, merchants, and the operators of other business enterprises, it could afford a convenient check on the status of their business. It could also serve as a quick but temporary means of recording phone numbers until a permanent braille record could be made. For a blind homemaker, it could cut down tremendously on the time required to total up the family's bank balance. In short, if blind people are to keep pace with modern man as he hurtles into a space age technology, it may turn out that our staunchest ally will be found in the centuries-old, yet vitally new, abacus.

MISCELLANEOUS EDUCATIONAL AIDS FOR THE BLIND

MAURICE D. OLSEN
American Association of Instructors of the Blind, Inc., St. Louis, Missouri

Granted that quality teaching and professional personnel are of the highest priority in importance to any educational program, and that administrative organization of curriculum, courses of study, or schedule of offerings are also of great importance; it remains true that the area of facilities, equipment, and educational materials is a contributing area of concern in working toward quality education to be offered blind children of our nations. Assuming the provision of an adequate school plant, buildings and campus, or major physical facilities for housing a school or educational program, we are interested in this paper in reviewing educational equipment, aids, or materials needed to furnish these buildings and classrooms. The scope of this paper will not include discussion of texts and supplementary reading materials, the latter furnished mostly by the libraries for the blind. However, two areas will be introduced immediately that may be considered educational aids, and which concern text and library materials: these are illustrations and museums.

The entire problem of the relative absence of illustrative material in braille and recorded text and library materials indicates a need for adapted and special purpose devices as educational aids. Much individual effort and organized producers' attention have been spent in trying to compensate for this lack of illustrative material (pictures, diagrams, charts, maps, representations, graphs, etc.). The major developments, it seems, have been in the areas of (1) relief, raised lines, punctiform, or braille maps and diagrams, and (2) models, replicas, and tactual representations.

New and different methods of vacuum forming of plastics and the use of solid plastic ink are now being used and investigated in addition to the embossed paper techniques that have been extensively used for some time to produce such illustrations. Vacuum forming has been successful in producing representations in relief that can extend over an inch above the surface plane. This presents problems when attempting to include these illustrations in books but this method has been highly successful for desk maps and many other possibilities are being recognized for this process. Also, handmade individual copies of maps and representations made from the combination of such tactual materials as screen, wire, thread, yarn, cloth, sequins, beads, sandpaper, etc., can be duplicated in many instances with vacuum forming equipment. This entire field of illustrations, models, and educational aids still needs study and research to assure that the materials developed are educationally correct and valid in presenting the intended message to blind children. The amount of detail, the need for exact duplication, the use of exaggeration for effect, the influence of substituted material, changed surface, structure, and size are all considerations that may change the concept that is received by the child. These factors may either emphasize a lesson or educational communication—or distort, destroy, or confuse such a lesson. The judgment of the teacher continues to be a necessary factor in assuring that educational aids will accomplish an optimum transfer of intended meaning.

In addition to relief and raised line illustrations to accompany or supplement text and library materials, there has been considerable contribution made to the education of blind children through the use of models and museum artifacts. In the educational experiences of blind children there is a place for classroom museums, school museums (many times administered under the responsibility of the school libraries which are becoming centers of instructional aids), and community museums. We can omit from this paper that segment of museum aids concerned with real, sample, or actual examples of the objects themselves, although they are extremely useful in the education of blind children. This leaves the area of models and replicas as a responsibility of educators; and for imagination, considered evaluation, and hopefully, cooperative group action to be used in their production and distribution. Some of these needed models can be obtained from the growing supply being offered through regular educational supply companies. Some of the recent science and biology models are excellent for use by blind and sighted students although all such aids should be subjected to rigorous evaluation for their use and interpretation by blind students. The word "adapted" in the panel title for this group of meetings should remind us, however, that materials that are commercially produced and which we evaluate for use in our special programs need not be accepted or rejected in their totality. Therefore, we should make efforts to overcome or remedy their individual faults or to discover the appropriate use that could be made of these educational aids.

In a review of the need for aids in the education of blind children we can start with the elementary grades. Preschool aids such as commercially available books giving actual practice with dressing skills and using real buttons, zippers, snaps, buckles, etc., can be purchased or made. In early school experiences, one of the areas of use for special devices is with material used in reading readiness programs to teach finger dexterity, strength, coordination, and skill. Many of these items may be found in any primary grade classroom and are not necessarily the special property of educational programs for blind children. Beads, blocks, clay, construction sets, etc., are included in this category. Another activity carried on in lower elementary grades concerns the student's discrimination. There have been materials developed in this area for instruction using all the senses, including smell, taste, touch, and hearing, and using student activities of comparison, measurement, and other differential judgments. There are bottles containing various aromas; there are squares covered with different materials and having different surface textures; there are wooden cylinders containing rolling beads or fine particles that make sounds when shaken; and other sensory training devices can be used to match or pair, select the different one in a series, and rank in order of pitch, roughness, etc.

Language development is important in lower elementary grades for reading readiness but activities concerning language are conducted mostly on a verbal level with little use of special educational aids other than disc or tape recordings. Concept development is also important to reading readiness; educational aids in this area fall mainly in the category of models and museum articles. Live plants and animals and other real or actual items such as coins and household items are important in teaching concepts. Tactual representations of flags and other common objects are often used in the education of visually handicapped children. The specific program of braille readiness often includes the use of articles such as six-compartment toy muffin pans, pegs and pegboards, discs, and other early representations of the braille cell and braille dot combination possibilities. In the elementary grades, after braille has been introduced, the teacher may make use of braille flashcards and games. These flashcards have sometimes been handmade, using durable, washable plastic found in used and discarded dictating belts or discs. The flashcard and other educational games are sometimes specially developed for use with blind children and other times are simply adaptations of commercial games produced for use with sighted students. Braille dice are also available for use in educational games. Although many audio-visual aids are used with sighted children, special audio aids have been developed for use with blind children. Most nations have definite special programs of tape and disc recorded educational aids for use with blind children. Blind children can quite often gain from good audio-visual materials such as educational sound movie films. When these aids are well organized the sound portion closely follows the visual part and the subject material is explained lucidly. We should always be alert to new developments and aids in the field of general education for adaptation and use with blind children, but there is need for evaluation of these aids by trained professional personnel experienced in the education of blind children. A case in point would be the recent experimentation with educational classroom television which is being carried on in some schools for the blind. Though television is quite visually oriented there may be some definite benefits to be derived from certain well-planned adaptations and uses of classroom television.

It is important for special educational aids for blind children to be attractively designed and colorfully produced for the benefit of partially seeing children who may be in the same classroom, or so that these aids may be used in programs where blind children are being educated in regular classrooms with sighted children. In special cases the teacher may develop special braille calendars for the bulletin board or for use in illustrating the monthly changes of the calendar, but with the numbers and information represented in print and in braille for use with partially seeing or fully sighted classmates.

Elementary arithmetic aids such as the abacus, counting frame, braille calendars, clocks, dice, rulers, and compasses have been adapted for use with blind children. Friction devices are sometimes used on the abacus and braille markings on other measuring devices. Science aids such as thermometers, barometers, etc., are also available from some sources in adapted form for use by blind students. Two other educational aids which have been successfully adapted for use by blind students are the flannel board and the magnetic board. Use of these two methods of presenting tangible representation is limited only by the creativity of the teacher. Both of these boards can have cloth, metal, plastic or other three-dimensional items as visual representations, or illustrative items that will adhere to the vertical boards, held by either magnetic attraction or adhesion of pieces of flannel cloth to a large flannel cloth backing. Pictures with movable parts can then be manipulated by teacher and pupils.

In elementary arts and crafts blind children can use raised line drawing materials available from special aids supply sources or made at home. Those kits generally for sale have a rubberized drawing board over which a ball point pen will make tiny ripples on plastic sheets, while homemade boards may also have rubber (possibly from tire innertubes), cork, or metal screen backings, and can be used in the same way even with paper instead of plastic. Spur wheels are also used to perforate paper but the results of such efforts must then be turned over to be read or followed by students since the perforations are made from the top of the paper to the bottom. Painting, pasting, clay modeling, etc., are all possible without special equipment.

In physical education in the elementary grades there is much in the way of gymnastic equipment, regular physical development aids, and other materials that can be used with little adaptation to blind children. One important development is sound introduced to playing balls through bells, or a battery-powered device which emits a periodic "beep." The battery is rechargeable by the regular electric supply and the sound is emitted constantly after a pin has been removed, even when the ball is at rest. Sometimes sound can be added to regular playing balls by inserting a bell in the bladder of a ball, or by fastening a bell on a rubber band stretched across the inside of a plastic ball that has holes perforating the surface. Sounds such as from metronomes have also been used to locate targets such as basketball backboards, archery targets, etc.

In high school more elaborate and specialized educational aids are needed. Maps and globes are available in a wide range of types and for different purposes, as there are many maps and globes needed to illustrate all possible political, topological, climatic, sociological, historical, and other lessons. There are needs for maps of the school grounds, local communities, and local intermediate political divisions that often must be met by local volunteer production since the needs are limited and local. Globes are available in varying sizes and with different types of information. There are puzzle maps, relief or contour desk maps, atlases, a quarterly map service in magazine form, large floor-type relief or contour globes, table-top relief globes, and label kits for marking maps and globes. Recently more of the commercially distributed wall maps and table-top globes are being made in relief and can be used in the education of blind children after careful evaluation and teacher planning.

There are aids used in teaching script writing that include a variety of writing guides and raised-line paper and forms such as raised-line checkbooks. Some educational aids have been developed to help in the organization of materials in school work such as specially designed large size desks, or study centers, bookholders, storage facilities, etc. Writing equipment is covered in another paper of this Panel but there are a variety of braille writing machines and slates, including upward-writing slates, in addition to braille erasers made of wood, bone, metal, or plastic.

In business education there are special shorthand writers and regular typewriters and dictating equipment are used. There is a product that can be used to erase typewriter errors if the errors are caught immediately. Chalk-surfaced paper is inserted over the error, the typewriter carriage is backspaced to the space in which the error was made, and the wrong letter is struck again; this causes the white chalk powder to transfer to the paper and covers the error. After backspacing again, one may then retype the right letter over the "erased" wrong letter.

For weaving, there has been a device developed that causes an electric signal to sound when a thread breaks. There are special guides to help blind students write print music. There have been attempts to develop racks to hold horns having three valves so that a hand and an arm may be freed to read braille while the horn is being played. This eliminates the necessity of memorizing music for students of the few horns equipped with three valves.

An entire paper could be written simply on tests that have been developed for use with blind children; however, I will not try to discuss this subject in this paper.

In addition to obvious travel aids such as the various canes, some educational programs have developed balance beams and other devices to correct veering tendencies, posture, etc., in blind children learning mobility skills. For teaching mathematics there are braille slide rules, adaptations of computers, geometric aids, etc. Some aids for geometry make use of pins which can be inserted on materials like rubber, marked in raised line squares, to which rubber bands, string, or flexible metallic bands can be attached among the pins in various positions and shapes. For teaching science, many commercially available educational aids such as skeletons, torso and anatomical models, biological models, etc., have been developed, but there is also need for additional development of similar educational aids for blind children.

In prevocational departments in schools educating blind children, devices are used which are covered in papers on vocational aids in the areas of industrial arts, piano servicing, physical therapy, home economics, shoe mending, etc. For home economics there are special adapted measuring and dispensing devices for liquids, powders, etc. There are slicing and cutting tools for adjusting a knife attachment guide for different thicknesses of slice, or furnish a bread-cutting box guide or pie-cutting guide to help direct the knife. There are self-threading needles and needle threaders, hem gauges and tape measures, timers, markers for canned foods, pressure cookers with braille controls, etc. For the industrial arts there are guides and specially adapted tools such as levels, rules, steel tapes, squares, marking gauges, angle dividers, calipers, micrometers, brad pushers, tire pressure gauges, saw guides, drill positioners, etc. In electrical work the Auditory Circuit Analyzer and other tools have been developed.

Many tools and devices that are helpful to the blind need no adaptation (such as pie-slicing guides used by sighted housewives); others need only braille markings and calibrations to become useful (as for clocks, timers, rules, etc.); still others may include special additional adaptations such as the flip-open covers designed for wrist watches in addition to the special braille markings (the watch works are identical to the standard item).

For high school physical education there are tumbling safety belts, trampolines, and other gymnastic equipment that need no special adaptations. There has been some use of bicycles tracking on a circular path at the ends of long arms, while other educational programs use tandem bicycles with sighted or partially seeing students steering the cycle. Other schools encourage use of regular bicycles in open areas free from obstacles or even on circular tracks with auditory clues to the riders at the curves. Bowling rails have helped students guide their efforts in this sports activity. Baseball diamonds and other field games with boundaries and other surface markings have been played with asphalt running paths or other pedi-tactual cues being used to help students travel during the sport or game.

Although this paper has not covered all the educational aids used with blind children, I hope that a sufficient number of these devices have been mentioned to indicate the many areas in which special purpose or adapted devices can be designed with teacher creativity, resourcefulness, and ingenuity. We might hope that professional communication of successes and failures that have taken place in individual educational programs will be increased so that knowledge and information can be rapidly shared and communicated. It is hoped also that increased use can be made of central sources for mass-produced educational aids that have been found valuable enough to suggest demand in numbers. I hope sincerely that members of this Congress will work toward the identification of an international clearing house for such information on the availability of, and need for, these special purpose educational aids for use with blind children.

TYPHLOLOGICAL SYSTEMS FOR THE USE OF THE BLIND AND THE VISUALLY IMPAIRED IN EDUCATION

R. C. MURATOV, O. L. ALEKSEEV, M. A. VERBUK
and N. V. MOSTCHENNIKOV
Institute of Defectology of the Academy of Pedagogical Sciences,
Moscow, Russian Socialist Federated Soviet Republic.

The total or partial loss of the faculty of vision has a profound effect on a person's entire way of life. Through communication with others and interaction with the environment, however, he is able to work and to find material and spiritual values.

This is accounted for by the appearance and development of compensation processes involving the formation of functional substitutes and the establishment of compensatory rearrangements in the nervous system as soon as a visually handicapped person takes part in intellectual and social activities. These processes are conditioned by the environment as well as the structure of the impaired functions and the peculiarities of the individual.

Special research is devoted to these exceedingly complicated phenomena in the Soviet Union. Soviet defectologists have proved by their investigations that a person with visual defects can formulate adequate ideas and conceptions. These investigations show that it is possible with scientifically grounded educational facilities and technical assistance to overcome a handicap and to achieve effectiveness in intellectual and vocational activities. Children with visual defects study at special schools and acquire the same knowledge as seeing children. The nature of their handicap naturally causes certain difficulties but they are overcome through the application of special technical facilities (typhlotechniques) which assist in the perception of the material to be studied.

Typhlotechniques employ technical devices which enable a blind or partially sighted child to obtain information about his environment and which restore in him the ability to influence his surroundings.

In cases of the impairment of individual functions of the visual receptor it is often possible to restore technically the lacking information by modifying the light signal. Any noise due to the inherent defect in the receptor will remain unchanged but the signal/noise ratio may be increased. Thus a technical correction of vision is possible. The increase in the resolving power of the eye in a partially sighted person by means of optical aids may serve as an example.

The general requirements of aids for partially sighted persons are that they increase the efficiency of the eye and decrease the harmful effects resulting from strain on the eye. The optical and lighting instruments for the partially sighted are intended to provide correction for ametropia, astigmatism, asthenopia, and the strains resulting from excessive accomodation and convergence. This group includes corrective and protective glasses and optical aids. We can also provide for the viewing of very small objects at a large angle of vision or the viewing of such objects on a screen with the help of optical systems, including magnifying lenses, microscopes, binoculars, and slide and motion picture projectors. We also assist in providing general illumination and the illumination of working space, using reflectors for general and local illumination and for classroom lighting features.

In a number of cases enhancement of the signal by technical means is impossible in view of the fact that certain elements of the visual receptor have been destroyed. In these cases a substitute for the visual receptor functions is needed. It is necessary to substitute, for the signal which a blind person is unable to perceive, an aural or tactile signal which he can perceive.

Portable and stationary devices employing photoelectric cells have found their way into educational programs. In these devices the characteristics of objects are translated into audible signals. The photoelectric device used in schools provides for the observation of distant objects (the viewing of clouds in the sky, the horizon, observations of the visible motions of the sun and moon, etc.) as well as the observation of nearby objects. It also permits detection of objects concealed by a transparent obstacle, e.g., detecting the level of a fluid in a measuring glass, the position of the pointer on a meter, etc.

The principle of hand scanning is used since it enables a blind person to make a minute observation of the surfaces of objects by estimating the intensity of the reflected light from the various points comprising its surface. Thus a blind person can locate objects in space and construct some image of them.

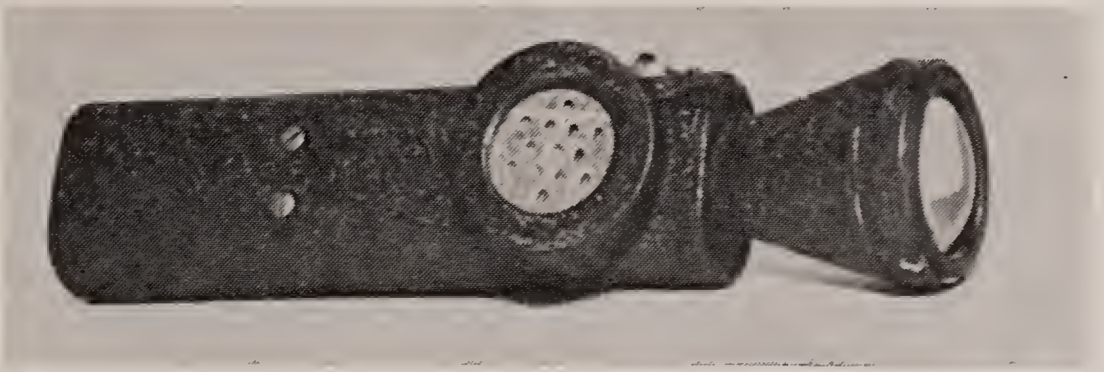

FIGURE 1 Portable Optical Probe Using a Photoelectric Cell

Figure 1 shows a photograph of a portable instrument of this type. It consists of an optical system which detects light intensity photoelectrically and transforms this signal into an audio signal of varying frequency. Thus the changing pitch of the signal indicates the gradations of brightness in the environment, while the direction of incoming light is perceived kinesthetically by manual aiming of the device.

Blind pupils undoubtedly have the ability to formulate some visual images which, if their reports are at all reliable, are analogous to those obtained directly through vision. We have attempted to determine if a blind person is able to make a rough topographic map of a locality. Such a map would be of obvious importance in the independent orientation of a blind person in outdoor life.

The stationary model of the photoelectric device (Figure 2) is designed

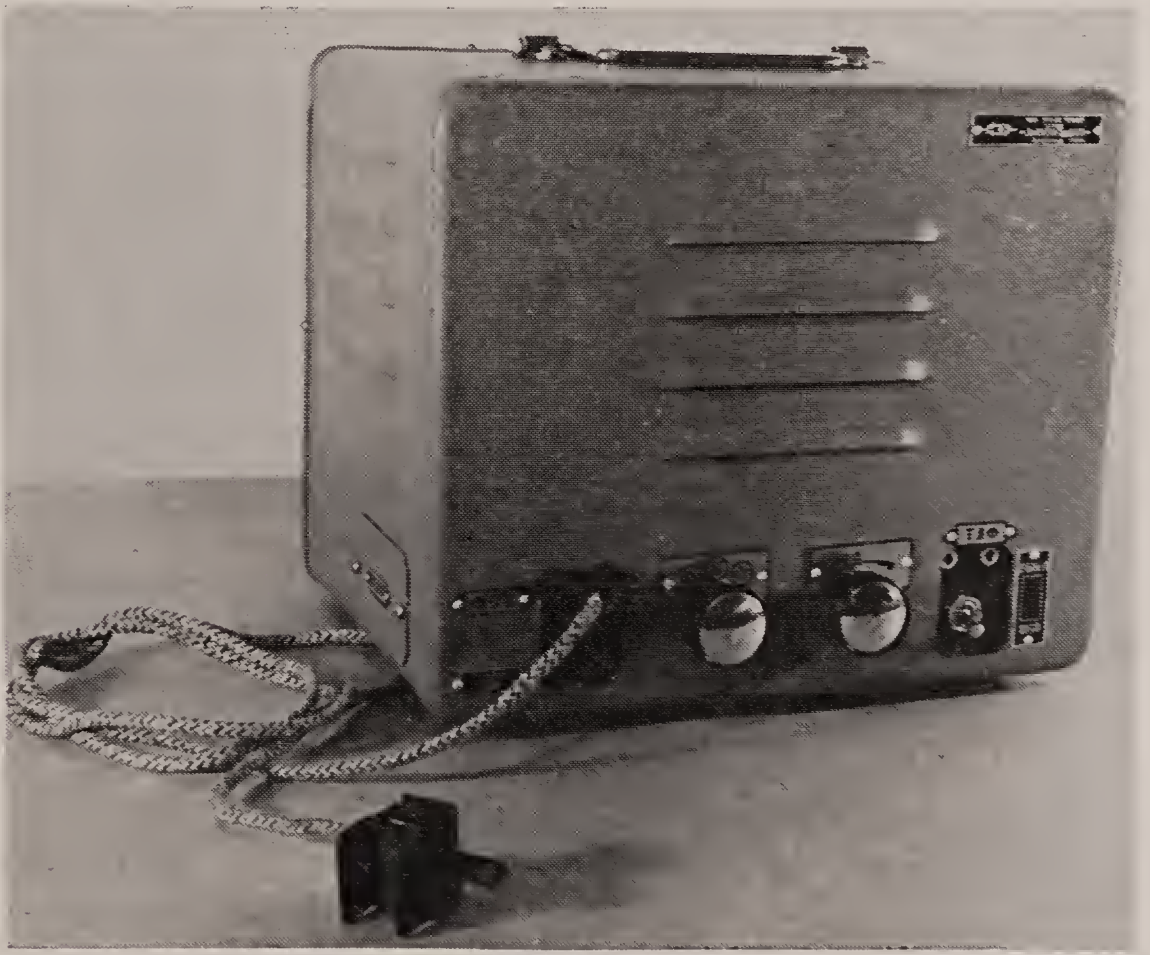

FIGURE 2 Stationary Optical Probe Containing Additional Switched Output Signals

specifically for use under conditions existing in a school for blind children. Basically it consists of an electronic unit which generates an audio signal that is transmitted through a loudspeaker. The electronic unit is placed in a metal housing. The current generated by light received through a photo cell is fed to terminals on the housing. An audio signal is generated when light is received from an object. When the object is dark the tone is of low pitch and the lighter the object the higher the pitch becomes.

The presence of additional types of signals distinguishes the stationary model of the photoelectric device from the portable model.

There are occasions when the continuous audible signal is undesirable. By turning a switch the signal is changed to a signal of short duration which is present only when the light receiver crosses a border between light and dark areas. Such a signal is very helpful in determining the quantity of colored liquid in a glass vessel (Figure 3) or in determining the position of the pointer on an electric meter (Figure 4). The readings of the quantity of liquid or the deflection of the pointer are taken by means of embossed scales. By turning the switch again the signal appears only when the light receiver is pointed at a light object. By employing this feature a blind person

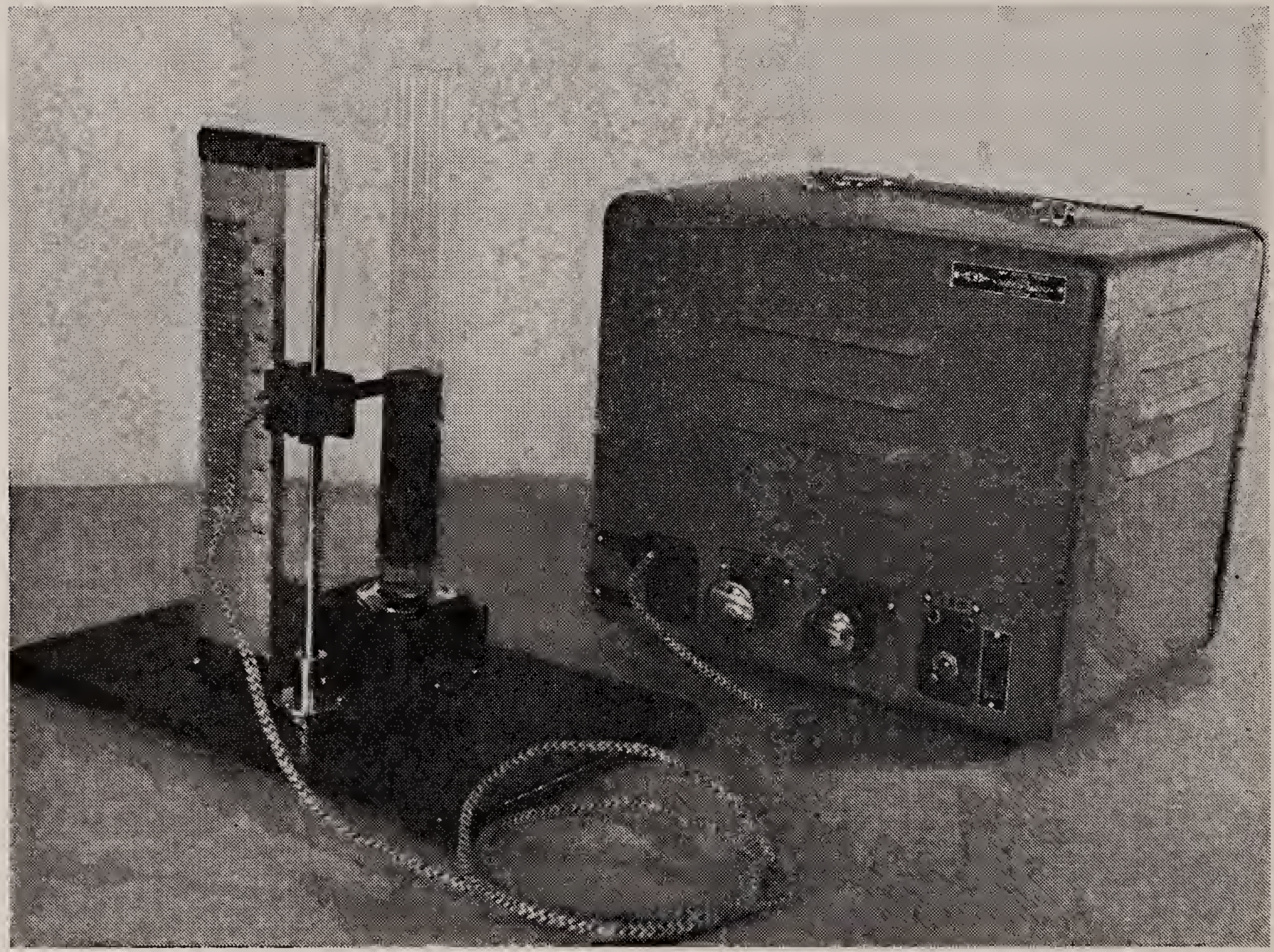

FIGURE 3 Using the Stationary Probe: Determining the Level of a Liquid

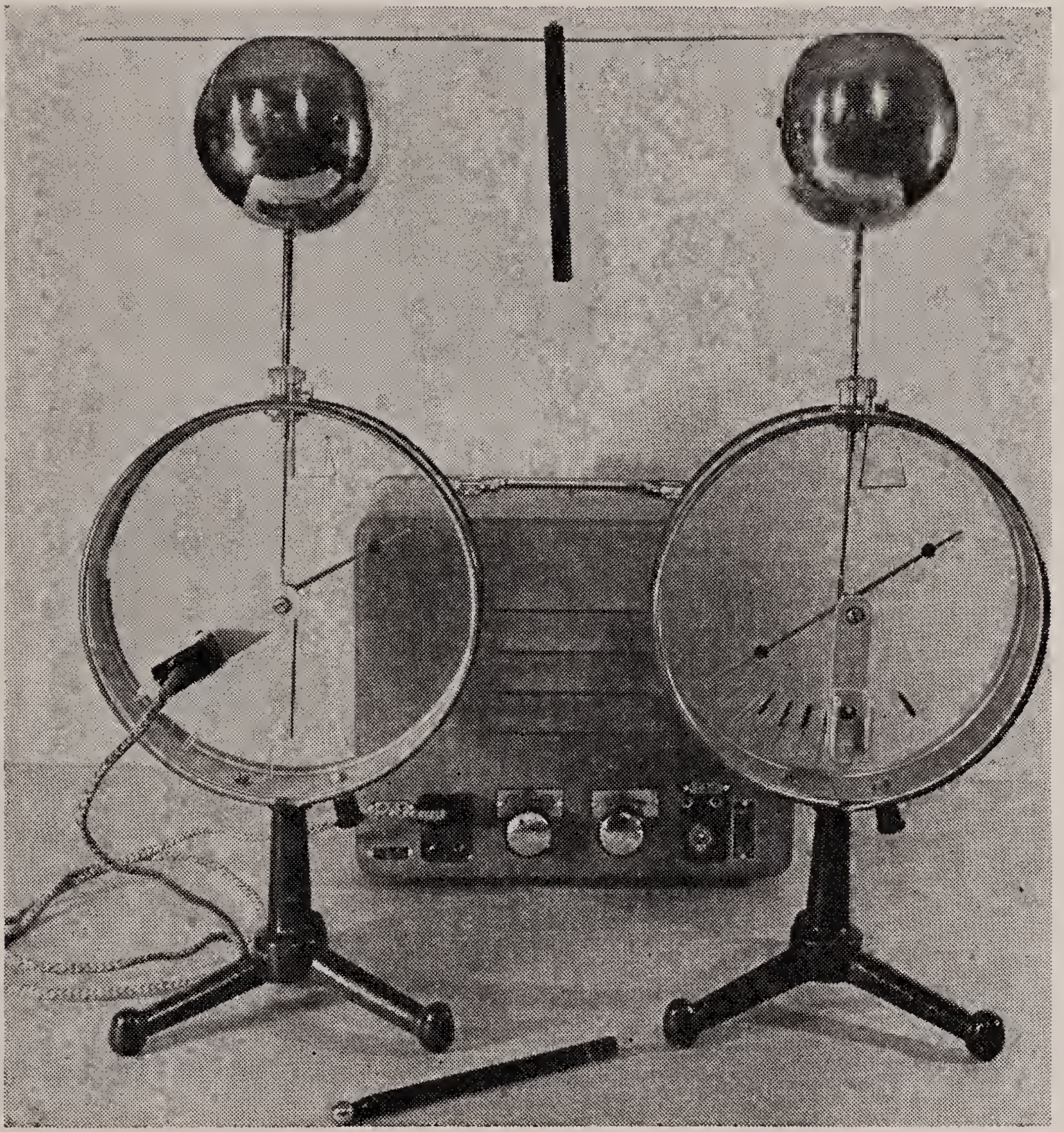

Figure 4 Using the Stationary Probe: Determining the Position of a Meter Pointer

can discover and determine the path of light rays in physical experiments with light (Figure 5).

For these experiments we use the same apparatus used in normal schools —a white screen, a reflector with a slit diaphragm, and a set of lenses and mirrors. When lenses and mirrors are placed in the path of light rays, the direction of the rays changes in accordance with the physical laws of reflection and refraction. To demonstrate the path of the light rays to a blind person the photoelectric device is used. When it is placed in the path of the light ray the audible signal appears. For a better demonstration the path of the rays is duplicated by a metal rod (Figure 6). Thus a blind person can tactually determine the path of the incident and reflected rays.

Due to the high sensitivity of the photoelectric cells, it is possible to demonstrate the law of luminance which enables blind children to make precise measurements of light intensity, etc.

Despite their simplicity these experiments play an important part in

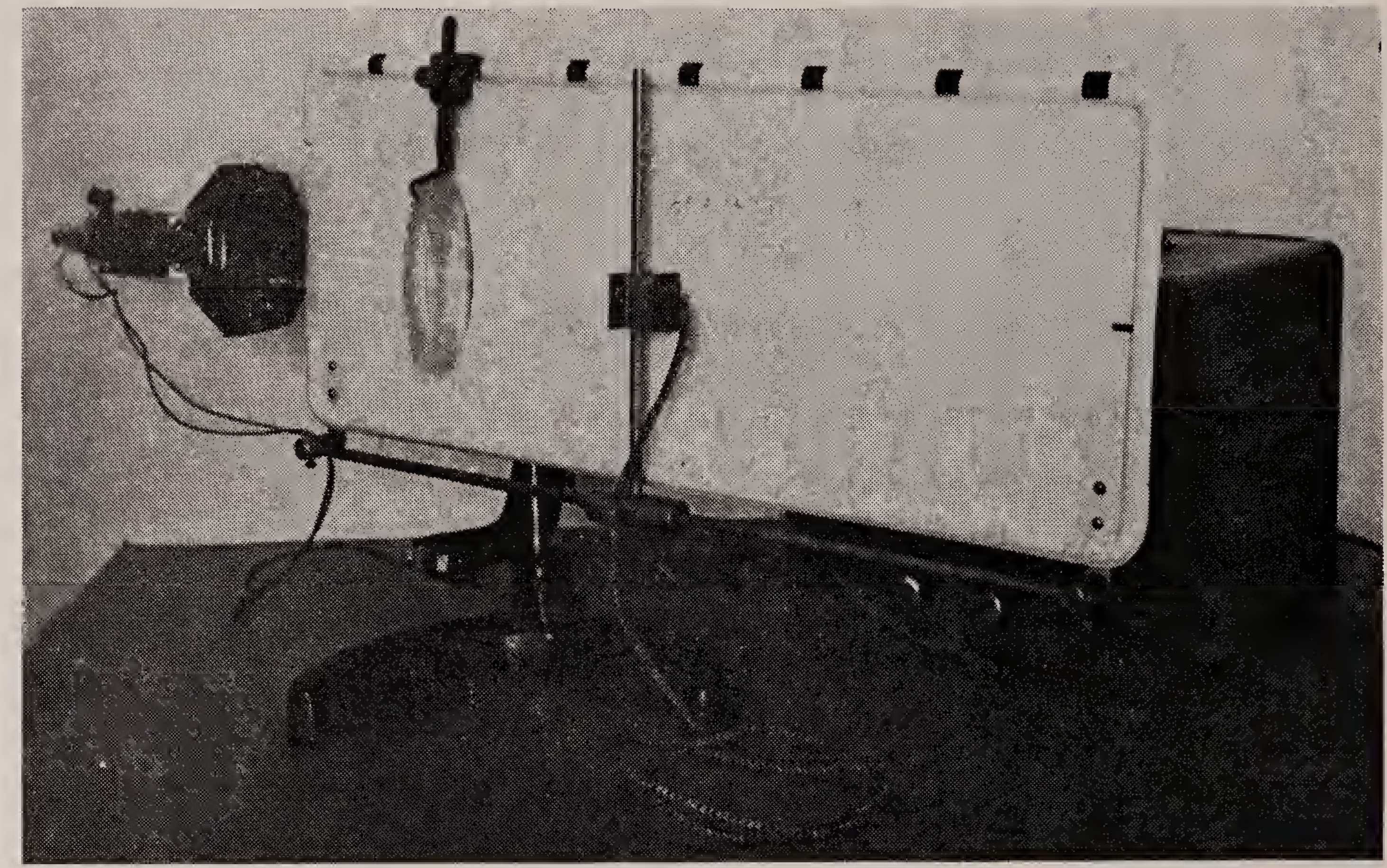

FIGURE 5 Using the Stationary Probe: Tracing Light Rays

fulfilling the basic didactic principles of the education of the blind regarding precision and independence in laboratory work. The use of the photoelectric device in scientific and other studies makes possible accurate illustration of the necessary material, allows active participation on the part of the pupils, and enables them to study independently subjects which had previously been taught only in a descriptive manner.

The instrument for reading printed text (Figure 7) is another application of the translation of visual characteristics into signals perceived through another mode. The graphic peculiarities of the letters are translated into either a combination of tones or a tactile stimulus. The text to be read is placed in a movable holder and pressed against a glass to hold it flat. The reader moves the holder manually forward and back. The optical unit may be moved by means of an electric motor along the line and, if necessary, by hand. Thus every letter of the text may be brought under the reading head.

The optically enlarged image is projected onto miniature photocells placed close together and aligned perpendicular to the lines of the text. As the reading head passes over parts of the image, electrical impulses from the photocells are fed to the tone signal generator. If the image covers several photocells simultaneously, a chord of several tones will be heard, in the earphones or loudspeaker. Thus for the letter "N" a chord of eight

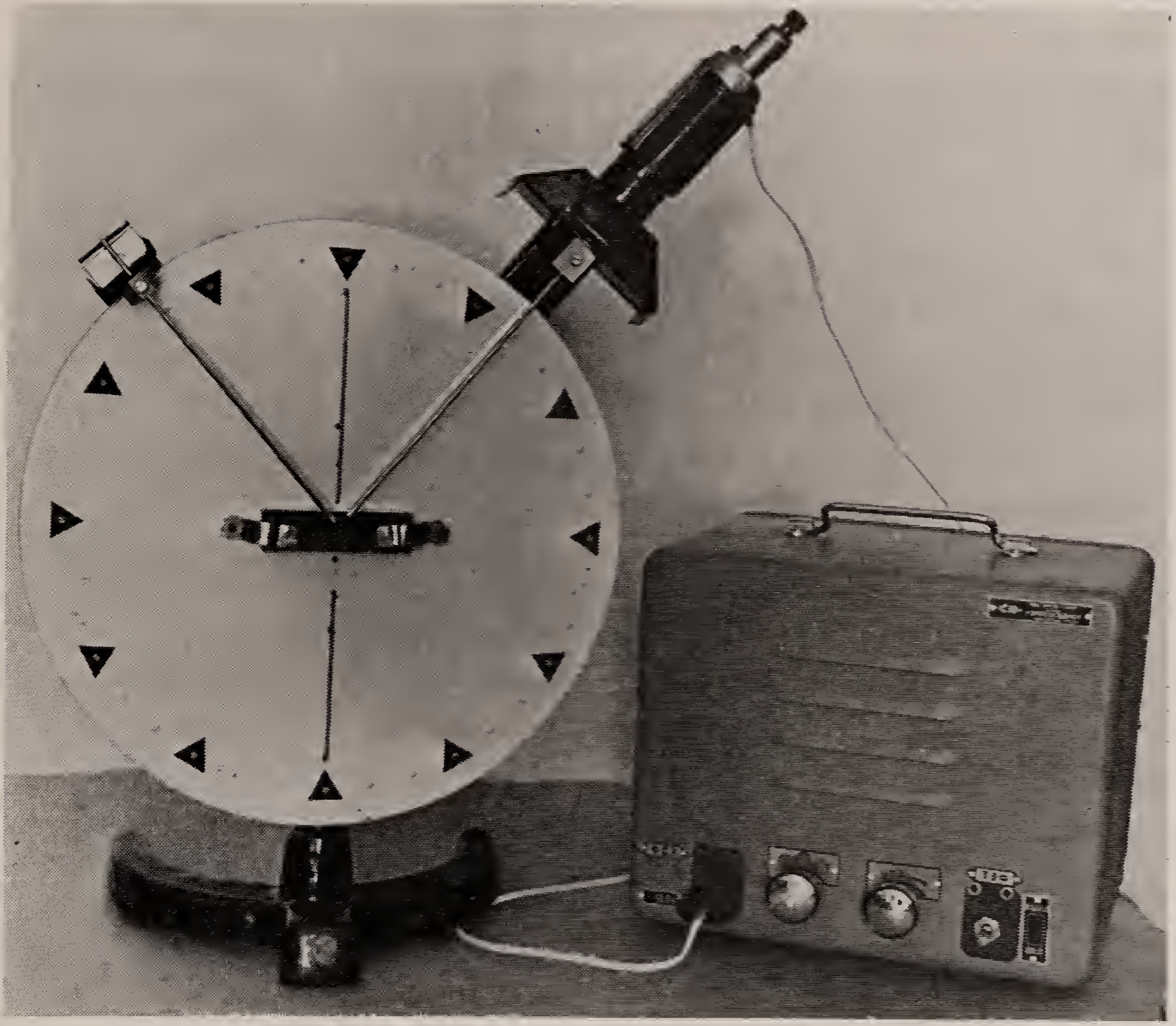

FIGURE 6 Using the Stationary Probe: Tracing Light Rays with a Tactual Aid

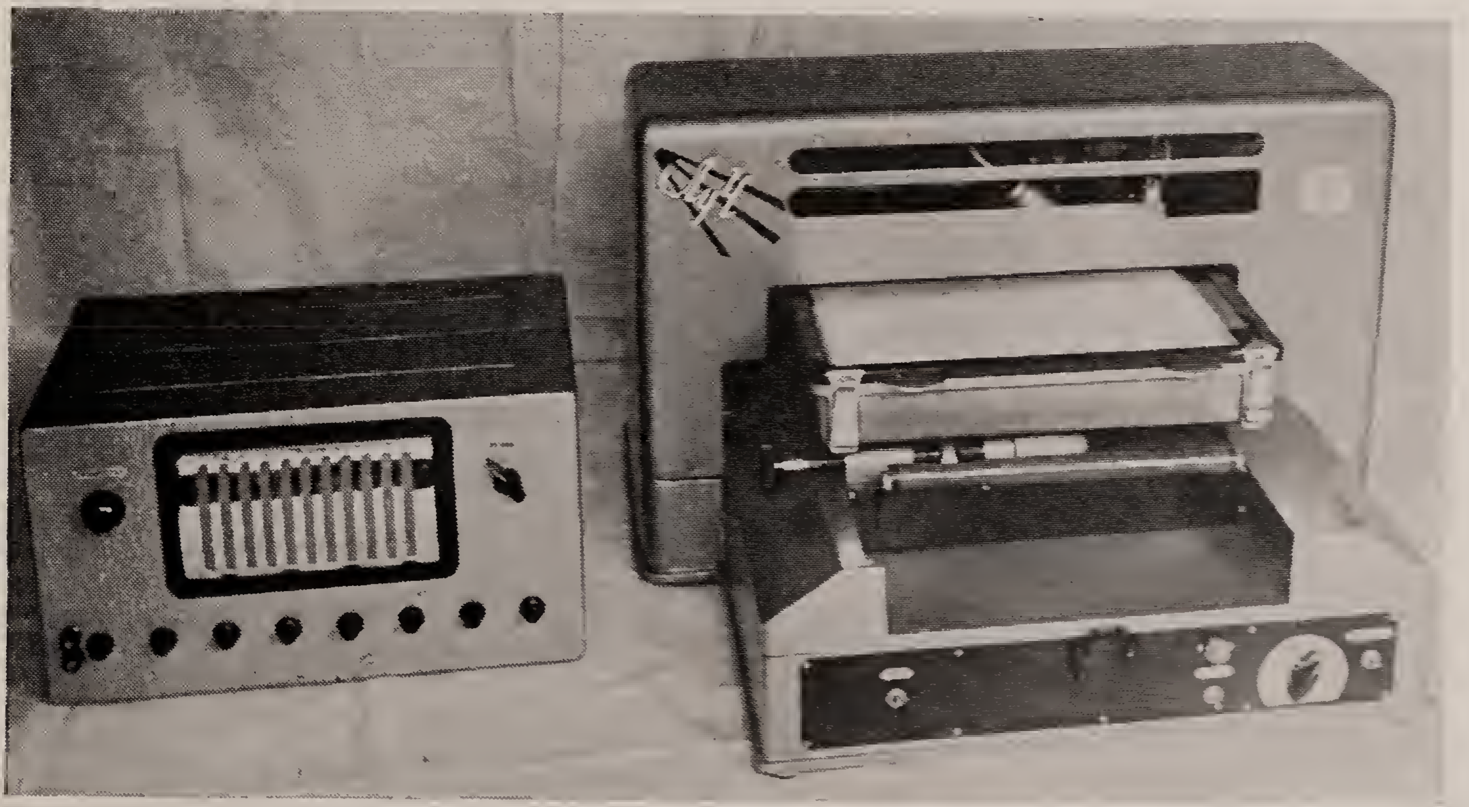

FIGURE 7 Reading Machine (Optophone Type) for Printed Text

tones will be heard first to express the first vertical stroke of the letter, then a glissando corresponding to the diagonal stroke, and finally another chord corresponding to the second vertical stroke.

Another model of the same instrument provides a tactile signal instead of an aural one. In this system, when the photocells pass over the letter image, metal pins are moved up and project from the surface of a special table. Each letter has its own combination of pins. Tactile instruments are particularly helpful in educational work with deaf-blind children.

The aforementioned instruments for reading inkprint have been designed in the Soviet Union and are undergoing tests at schools for blind children. These instruments are of interest not only in education but also in the solution of theoretical problems concerned with the formation of psychological processes in blind and partially sighted children.

A wide variety of aids adapted for tactile or aural perception is now in use at schools for blind. An indicator showing the flow of hot water in the heating system of an apartment house is one example (Figure 8). Relief maps and diagrams are another example. Figure 9 shows a relief diagram for laboratory work in electrical engineering.

Many schools employ sound signaling to indicate errors, for example in finding the location of a town on a map or indicating the presence of some phenomenon. Electrified scales with an aural signal indicating the unbalanced condition is of considerable interest to tutors (Figure 10). The application of typhlotechniques has made it possible for the blind to study such subjects as physics, mathematics, biology, chemistry, geography, relief drawing, etc. Schools for both the sighted and the blind have added technical facilities which enable them to teach such technical subjects as mechanical and electrical engineering. All this has contributed greatly to the realization of the polytechnical principle at schools for blind.

We have devoted considerable attention to typhlotechniques aimed at raising the labor productivity of the blind and making new professions and types of skilled labor available to them. The successful assimilation of new and complex skills requires better general and special training of the blind worker.

In order to attain this goal we must provide the necessary equipment and conditions for labor activities in the schools and provide the blind or partially sighted person with special technical aids which enable him to learn a skill. Due to the availability of these typhlotechnical facilities we are able to effect a general and special education of the blind and to solve the vocational problems of blind school graduates.

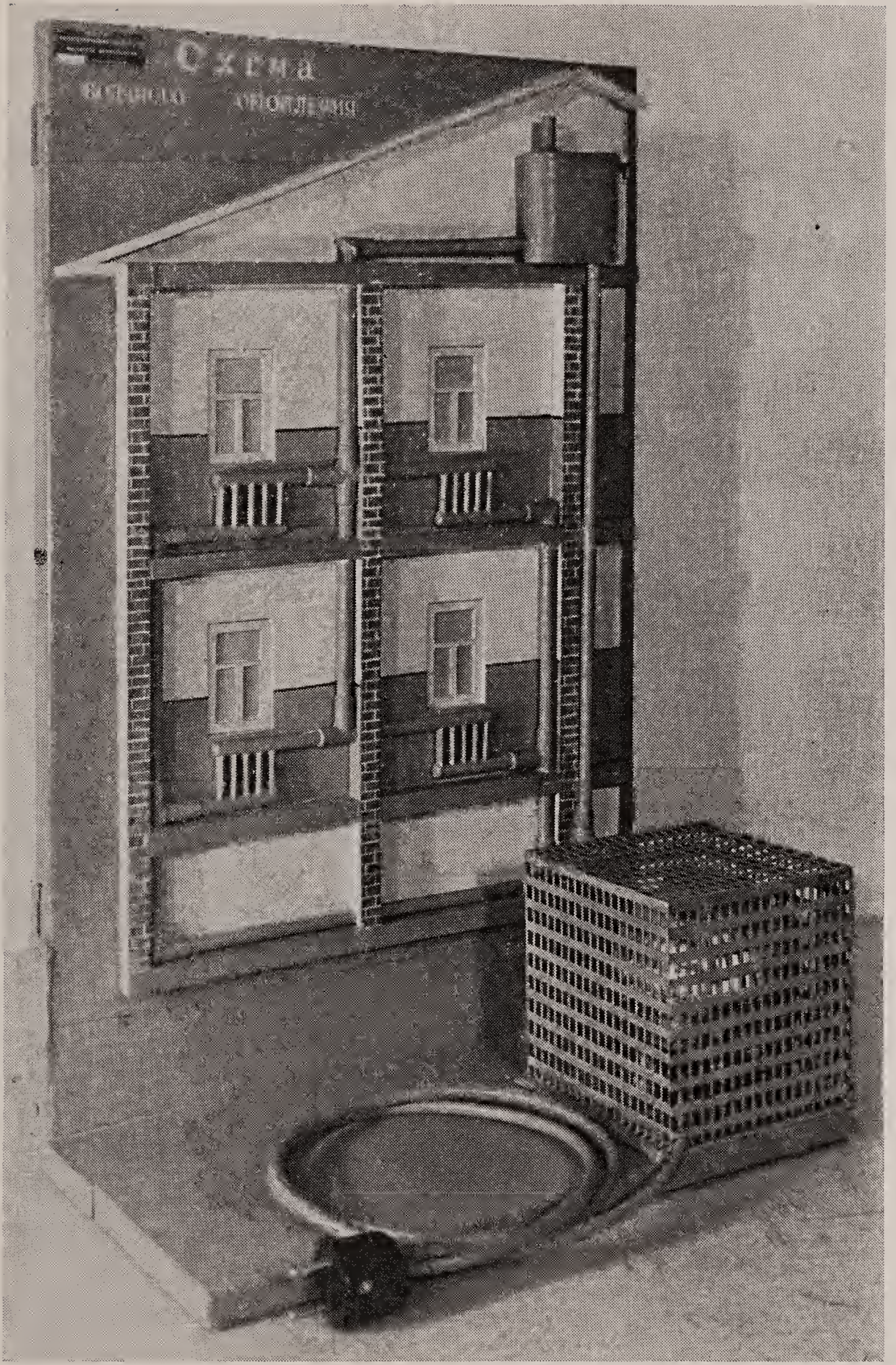

FIGURE 8 A Teaching Aid Depending on Tactual Information: Flow in An Apartment-House Hot Water System

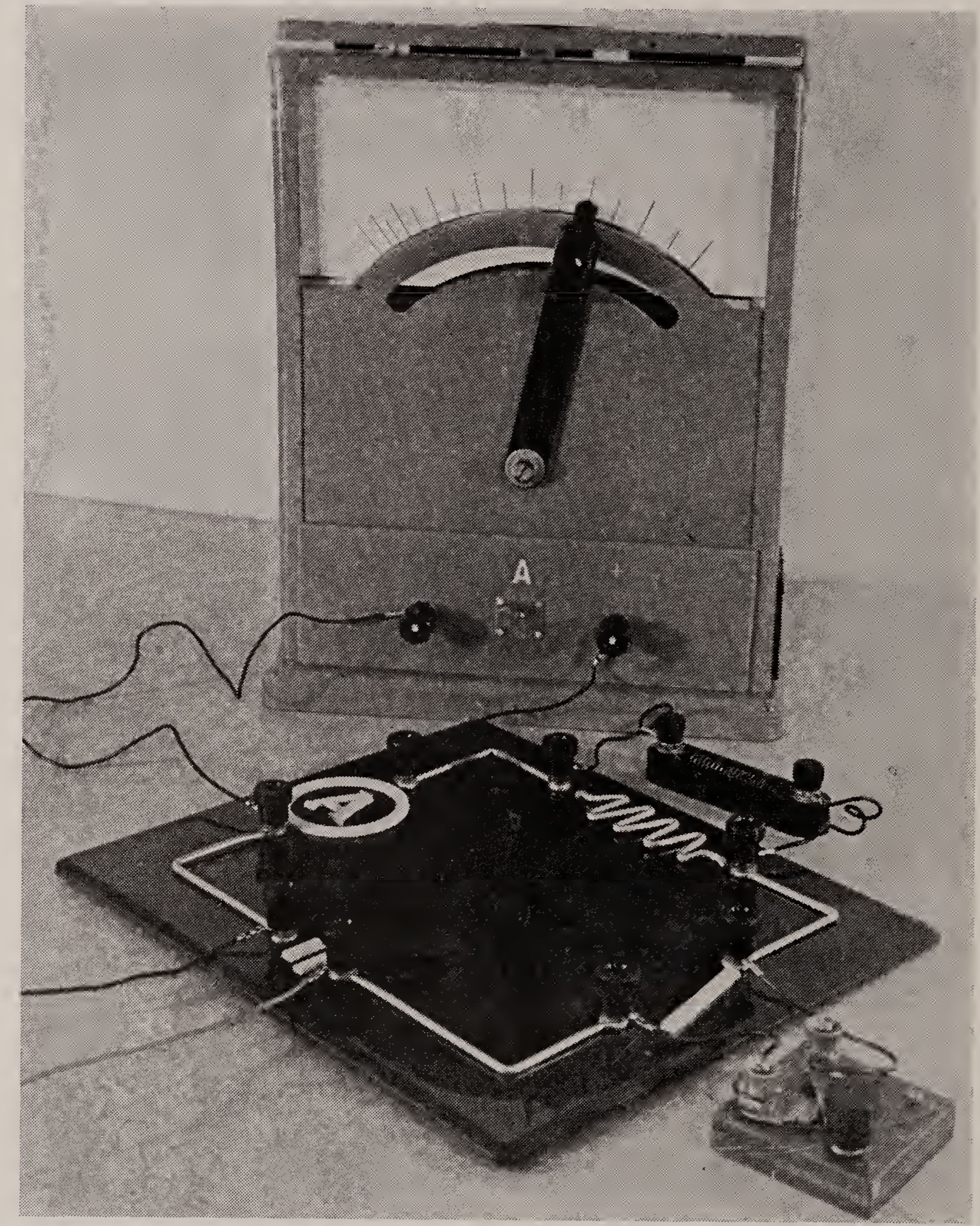

FIGURE 9 A Tactile Representation of an Electrical Circuit

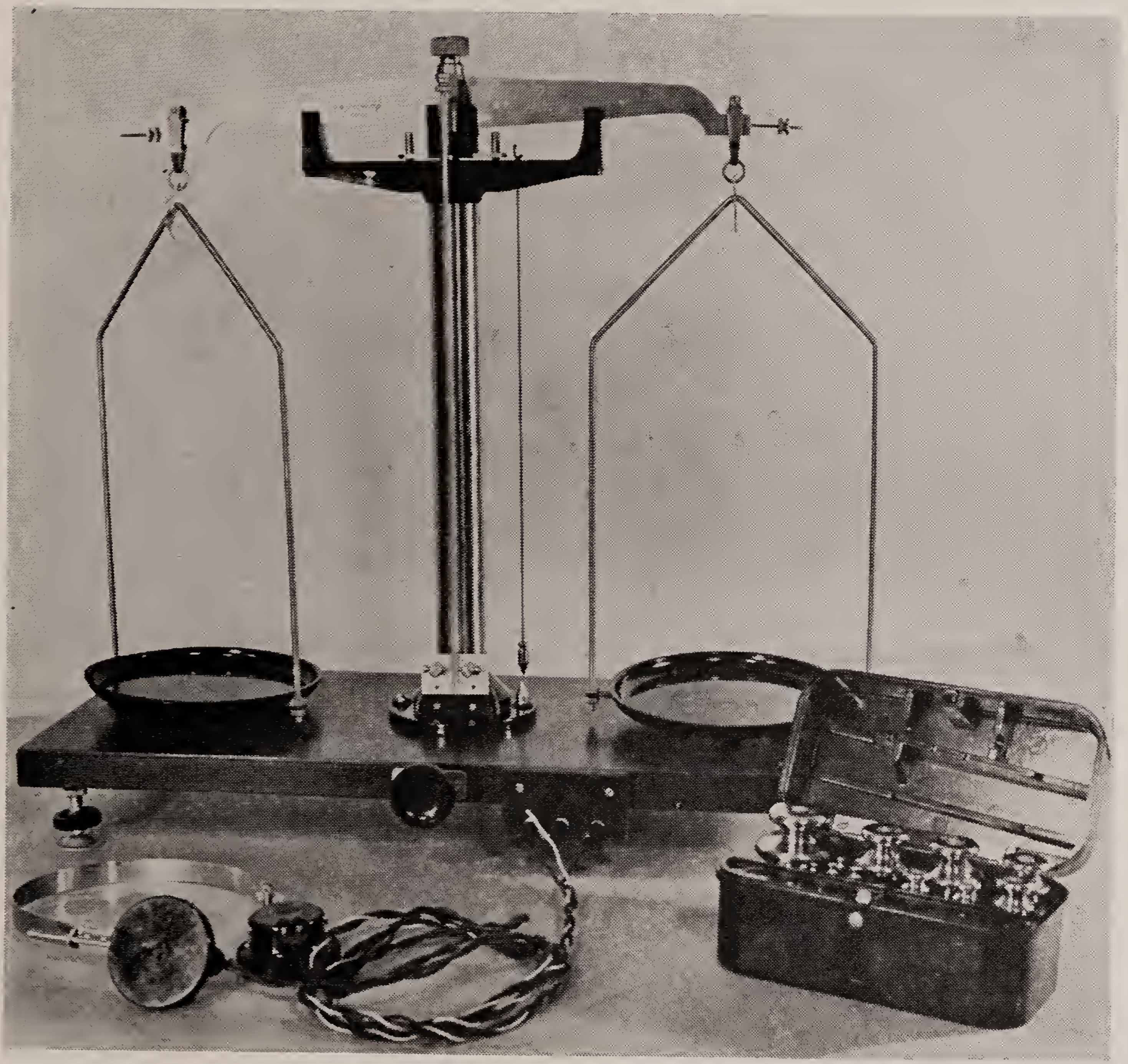

FIGURE 10 An "Audible Scale" in Which a Sound Signal Indicates a Condition of Nonbalance

PROGRAMMED INSTRUCTION AND TEACHING MACHINES IN THE EDUCATION OF THE BLIND

SAMUEL GEORGE ASHCROFT
Peabody College for Teachers, Nashville, Tennessee

The application of technology has led to great progress in the reduction of problems associated with blindness. Most such past applications have been confined to the development or modification of mechanical or electronic devices. These applications will undoubtedly continue to bring progress. Perhaps even more significant, however, are the potential benefits of the application of technology to instruction.

Finn (4) indicates that while the first industrial revolution contributed assembly line operations to industry, and the second included the invention of the method of invention, there was relatively little technological impact on education or instruction seen between 1900 and 1956. He marks 1955 as ". . . the date at which electromechanical systems analysis procedure began . . ." and he deems it no accident that our push toward space coincides with this date. He indicates that by 1950 American education had the potential to develop and apply a new technology to instruction. The hardware and equipment were available along with the systems concepts and a climate of incentive and public acceptance. The programmed instruction movement marks one aspect of a growing "technology of instruction" which many believe will have a profound effect on education. This movement should not be ignored by those in work for the blind and I believe it is quite appropriate to consider it here. Strong interest was shown in this topic at a recent conference on modern curriculum provisions for visually handicapped children and at a recent meeting of the Council for Exceptional Children where parts of this paper were read.

The programmed instruction and teaching machine movement is burgeoning because of the population explosion, the exponential rate of increase in new knowledge, the cold war, and the race for space. These developments are demanding progress toward an instructional technology.

These same phenomena will have their effect on the education of and work for the blind, but I believe the greater concern for us is the increase in the body of knowledge to be acquired by the blind person if he is to be an enlightened and effective citizen. Hardly anyone will deny that the blind person is at a disadvantage in the rate of acquisition of information and knowledge. As the amount of information to be acquired increases, steps must be taken to enhance the rate at which knowledge can be gained by the visually handicapped individual. About two decades ago we acknowledged this need in education and made efforts to meet it in the earlier and more general use of Grade 2 braille. Today we continue to try to improve in this area with the application of automatic data processing features and intelligent machine braille translation. A decade ago we began to think about the application of time compression to aural reading as a method of increasing informational input. The recent study by Bixler, Nolan, and Foulke (1) suggests promising possibilities yet to be implemented. While in no way attempting to detract from such important developments, I would urge us to turn some attention to the area of programmed instruction and teaching machines as an even more promising possibility for increasing the efficiency of imparting information and shaping the behavior of the blind. The benefits of these developments in programmed instruction and teaching machines seem promising in their potential to improve the efficiency both of imparting useful information and shaping behavior more efficiently for the increased use of technical devices and other aids to the blind. The efficiency of programmed instruction for imparting necessary information, such as the academic curriculum at all levels of the educational system, should liberate valuable time for blind persons to get other essential skills and information, to participate more fully in total social and cultural life of the community, and to be more constructive, contributing members of society. For example, it may be possible to reduce markedly the time now required by a blind person to learn college algebra or physics.

Many technical devices and aids for use by the blind have been slow to be accepted and utilized, at least in part because blind persons have not found it efficient or easy to learn to use them and because instructors were not available to help them. Programmed instruction seems to hold great promise for improving this situation. For example, it would be extremely productive to see what effects on rate and comprehension in reading with the Battelle Aural Reading Device can accrue from astute programming of the instruction. Programming applied to learning on guidance devices, such as an electronic cane, and to mobility and orientation training may increase our efficiency in these areas markedly.

The programmed instruction movement has yet to be applied to any appreciable extent to the problems of blindness. Though the movement is mushrooming in other areas, it is agreed that the surface is as yet only scratched as far as potential applications and benefits are concerned.

The essential features and characteristics of programmed instruction and teaching machines seem to make them entirely compatible with education of and work for the blind. In fact, the same essential features that characterize good teaching of the blind have counterparts in effective programmed instruction and teaching machines. Among the essential features that have been spelled out by Skinner and Holland (5) are:

1. The learner advances at his own rate.
2. The learner moves to advanced material only after thorough mastery.
3. The learner is almost always correct in his response because of the gradual hierarchical organization of the material.
4. The learner is continuously active.
5. The learner receives immediate reinforcement and knowledge of success.
6. The learner is presented items so constructed that the important and critical points must be reacted to and comprehended.
7. The learner develops concepts through many examples for maximum breadth of generalization.
8. The learner's responses provide valuable information for program revision.

The essential features of autoinstructional programs have been succinctly listed in just three points by Cram (2).

1. They present information in a way which requires the individual to make frequent responses.
2. They provide immediate feedback to the individual, informing him whether his response is appropriate or not.
3. They allow the individual to work independently and to adjust his own rate of progress to his own needs and capabilities.

As this writer attempted to point out in two recent papers, the principles and features of programming have useful applications for the instruction of the visually handicapped whether implemented with autoinstructional devices or as applied through everyday teaching practices.

These essential features are in accord with the principles of education commonly recommended for the visually handicapped. The first point suggests the active participation of the learner by requiring frequent responses. Individualized self-activity is a basic requisite of good instruction for the visually handicapped. In an effective program the subject matter is presented in an hierarchical organization of small units requiring active responses. The difficulty level is raised in small steps and the cues are diminished or vanished gradually until the desired proficiency level is attained. Behavior is shaped in small increments and increasing independent functioning is achieved.

Programmed instruction in meeting its second requisite, providing immediate feedback to the student, makes one of its strongest cases for appli-tion to the blind. One of the problems of the blind person is to monitor his own performance. He has difficulty getting reinforcement for successful performance. The blind person needs copious, objective, immediate feedback. Those who work closely with the blind know the crucial importance of constant feedback in order to help bring conceptions into line with objective "reality"; to enable the blind to adapt successfully to complex environments, both physical and social. The importance of immediate reinforcement has been stressed by learning theorists and it has been estimated that to establish relatively simple concepts such as arithmetic facts that as many as 25,000 behavioral contingencies followed by reinforcement are required.

Feedback has additional significance as a cue for instructional planning. The importance of feedback in automation illustrates the point. Sophisticated intelligent machines utilize information fed back into them by the learner to adapt to circumstances as they change. Modern teaching machines, as Stolurow's model of the Adaptive Teaching Machine System shows, have a pacer-timer to adjust and control rate; they include a comparator to check accuracy; and they have a collator-recorder to collect response information. These components provide immediate and almost complete adaptation to the learner through feedback. At the same time the information is utilized by the programmer to modify the program toward increasing precision in shaping the behavior of the learner.

It is well known that the third requirement of teaching machines and programming parallels another requisite of good instruction for the blind. This is individualization in terms of the rate and capabilities of the learner. As we hope this paper suggests, carefully programmed subject matter is the critical feature of the teaching machine. In fact, the hardware aspects have at times been facetiously referred to as $5000 page turners. The definitive and ultimate guide to effective programming for the programmer is the student. The learner is the final authority on what comprises an adequate program. His changed behavior provides the ultimate criterion for the determination of programming.

There are essentially two types of programming in use today. They are not merely whimsically different mechanical innovations nor reflections of partisan allegiance to one school of thought or another. They result from different theories and philosophies of learning and teaching. They have evolved from extensive scientific laboratory experimentation. The two essential types of programming are the *linear* identified with B. F. Skinner (7) and the *intrinsic* or *branching* types identified with Crowder (3).

Linear programming uses a constructed response—"fill in the blank," "recall" or "sentence completion" type of item. The type of learning involved is sometimes called operant conditioning. It is in line with Skinnerian learning theory.

Intrinsic programming uses the learner's choice of answer to multiple response questions to determine the next material to which he will be exposed. The necessary program of alternatives is built into the programmed instruction itself. In this way the intrinsic or branching program utilizes errors, as well as correct responses, to develop knowledge and skill in the learner.

There are, of course, alternatives to, combinations of, and elaborations of these programs, each with its own advantages. There seem to be extremely few, if any, reasons why all the available types of programming would not be useful with blind persons. Perhaps the most promising for early application to work with the blind may be the linear, Skinnerian type of program.

Many sets of principles have been suggested for developing programs. As an example, Klaus (6) has listed 12 rules for programming, somewhat condensed and combined herewith:

1. require active responding
2. provide proper cuing
3. develop appropriate context
4. maintain small steps
5. provide careful sequencing
6. include frequent repetition
7. ascertain accuracy of subject matter
8. teach, don't lecture
9. evoke relevant responses
10. use appropriate quantity of material
11. don't assume too much knowledge
12. don't relate more than one fact at a time.

The writer is not prepared here to recommend any specific teaching machines or programs for use with the blind. Many machines are now available that would seem to be adaptable. Many conventional programs could be put into braille. Perhaps, for the immediate present, more should be done to apply principles of programming to everyday teaching.

Few specific applications for the visually handicapped have come to our attention. Those that have are apparently seeking to tap the market of the visually handicapped without providing much in the way of appropriate and necessary specialized adaptation.

One such application is from Automated Teaching Libraries of Kansas City, Missouri. A letter sent widely to administrators in the education of the visually handicapped announced the availability of automated teaching libraries for all subjects taught from grades 1 through 12 emphasizing science, mathematics, and foreign languages. The lessons are claimed to be useful for curriculum reinforcement and as sole source teaching. Each library is said to have 22,500 punched tape lessons each one half-hour long.

Quoting directly from the letter:

"The lesson tapes are read by a Central Control Panel which operates ten Student Study Units. Ten different lessons can be studied at the same time. The Student Study Unit is basically an automated typewriter which produces a typescript of the lesson studied. For the blind student, by touching one switch on the Central Control Panel, all lessons are produced in braille. . . .

"Any teacher can now instruct a blind student in any subject taught by using an Automated Teaching Library. Every subject has been programmed by a highly qualified professional teacher who is currently teaching the subject programmed. The knowledge contained in each subject and the teaching process is the same as used in classrooms throughout the nations today. Only the method of presentation has been automated. For the first time in history, a blind student will have equal opportunity to gain comprehensive education through use of an Automated Teaching Library. . . ."

An executive of Automated Teaching Libraries tells us the ten-station unit costs $85,000 and includes ten electric braillers for simultaneous presentation of brailled and printed lessons and the 22,500 punched tape lessons. All braille is presented in uncontracted form, letter for letter.

GUIDELINES FOR THE FUTURE

1. The potential benefits of programmed instruction and teaching machines should be explored in pilot study and research efforts.

2. People involved in work for and education of the blind should provide leadership, rather than waiting for action to come from others.
3. Programmed instruction and the use of autoinstructional devices with the blind should be viewed for the present as supplementary to rather than as replacements for conventional instruction.
4. Technical and mechanical equipment should be kept subsidiary to the program presented and its organization.
5. Programs for the blind should follow existing conventions for the presentation of literary braille, mathematics, and music, rather than altering familiar modes of presentation.

Efficiency in the teaching of the blind is essential in today's increasingly complex culture. The programmed instruction and teaching machine movement is being applied to problems in general education because of the population explosion, the expansion in knowledge, and because of the cold war and the race for space. It should be applied in education and work for the blind for its potential contribution to efficiency. The features of programmed instruction are similar to and compatible with effective instruction of the blind. The value of teaching machines lies more in their programming than in their mechanical aspects. Programming may lead to a psychologically sound technology of instruction which, when applied to the problems of blindness, may bring significant improvements. Applications for the blind should be subjected to rigorous research, should be subsidiary to conventional instruction for the present, and should follow current conventions in work for the blind. Leadership is essential and hopefully it will come from within rather than without the field.

REFERENCES

1. Bixler, Ray H., Foulke, Emerson, Amster, H. Clarence, and Carson Y. Nolan. *Comprehension of Rapid Speech.* Louisville, Kentucky: University of Louisville, 1961. (Cooperative Research Project No. 1005, Department of Psychology and Social Anthropology.)
2. Cram, D. *Explaining "Teaching Machines" and Programming.* San Francisco: Fearon Publishers, 1961.
3. Crowder, N. A., "Automatic Tutoring by Means of Intrinsic Programming," in E. H. Galanter (ed.) *Automatic Teaching: The State of the Art.* New York: J. Wiley, 1959, pp. 109-116.
4. Finn, J. D., "New Theory for Instructional Technology," in Smith, I. Wendell, and J. William Moore (eds.) *Programmed Learning.* Princeton, New Jersey: D. Van Nostrand Company, Inc., 1962, pp. 3-17.
5. Holland, J. G., and B. F. Skinner. *The Analysis of Behavior.* New York: McGraw-Hill, 1961.

6. Klaus, D. J., "The Art of Auto-Instructional Programming," *Audio-Visual Commun. Rev.*, Vol. 9 (1961), pp. 130-142.
7. Skinner, B. F. *Cumulative Record.* New York: Appleton-Century-Crofts, Inc., 1961.

TEACHING MACHINES:
AN HISTORICAL REVIEW

ALEXANDER SCHURE
New York Institute of Technology, New York, New York

The concepts of advancing teaching and learning through the use of technology are neither new nor revolutionary. One of the major steps in the process of using mechanical devices for dissemination of knowledge occurred more than 500 years ago when the printed book was introduced into the classroom as an end product of Gutenberg's invention of the printing press. We have become accustomed to printed text, so much so that our imagination finds it difficult to picture an educational situation existing without the benefits of print. Yet, from an historical perspective, it is far more likely that the present day electromechanical methods of storing and retrieving information, and of communicating this information, will lead to more important and more drastic changes in the nature of education and in the efficiencies related to it.

Mechanical devices used for instructional purposes have an extended history. In 1866 Halcyon Skinner patented a spelling machine designed to aid the teacher. Nearly ten years later, Jevons designed a logic machine, a device intended to generate solutions to logical problems represented symbolically. A number of additional teaching devices appeared on the scene in the early 1900's. It was not until the development of Pressey's self-scoring multiple choice apparatus in 1925, however, that attention really began to focus on machines designed to supplement classroom instruction. Dr. Pressey's device was about as large as a modern office typewriter and required the student to press one of four keys to answer questions displayed on rolls of typewritten or mimeographed sheets. Pressey's apparatus not only utilized principles which have become fundamental in the field of teaching machines (namely the principles of stimulus, response, and feedback), but demonstrated the fact that objective testing could be mechanized, thereby relieving the teacher of certain routine tasks.

Film and slide projectors, recordings (both tape and disc), and a number of other instruments have been used for decades in manners which permit presentation of information to the learner without the personal intervention or supervision of a teacher.

Although a number of improvements were made in teaching machines during the years from 1945 to 1948, it was not until quite recently that interest has become widespread and developments have been occurring at greatly accelerated rates. Psychologists, educators, training specialists, and engineers are increasingly involved in the field. Authoritative sources report that more than 100 new devices are in use as teaching machines and that many others are in process of development (1).

Another indication of the birth of the "teaching machine era" can be gathered by surveying the increase in interest in the teaching machine field during the 12-year span from 1948 to 1959. The number of published formal studies of consequence from 1948 to 1957 was less than ten in any one year, with the majority of years showing less than five published studies. In 1958, the number rose to 40. In 1959, it approximated 60, and, since that time, apparently is multiplying at a rate which promises to burden even the most modern descendants of Gutenberg's first printing machine.

Historically, sound reasons can be presented to justify the interest in this field. This is the age of the "breakthrough." Daily we read of exciting discoveries in virtually every field of science which, in turn, open pathways for even more exciting concepts. In most fields the growth rate of actual new product introductions and applications of techniques resulting from this vigorous scientific technology is described as exponential in form. In lay language "fantastic" serves as a less exact but perhaps more easily understood term to describe this phenomenon.

One prime reason for this amazing growth is the use of a different type of approach to many of the unknowns of concern to the scientific community. The researcher working alone in his laboratory, turning out invention after invention, has become a rarity. He has been replaced by a "team" consisting of a number of specialists in various fields who attack a particular problem by pooling their varied knowledge and talents. These teams have given us new tools which can be translated from field to field. Thus, in the field of medicine, the boundaries between biology, chemistry, physics, and mechanics have been interwoven to give us the concept of bionics.

One of the effects resulting from team applications within science and industry has been continuous and noticeable growth in both the productive capacity of the individuals working within a given industry, and the efficiency of the systems within that particular industry. One field, as we have seen, remained aloof from this frenzy of activity until just a few years ago—the field of education. Now the pleas of a few pioneers in the educational world are being considered, pioneers who had long urged the development of capital laborsaving equipment for educational purposes. The advantages of such devices have convinced segments of American business and industry sufficiently so that, in conjunction with the educational work, they are opening an entire new industry—automated teaching —which will change materially the educational techniques now in use.

There is little question that an excellent case may be drawn to justify the need for a new technique in education. The forthcoming population explosion will have a great impact upon the educational system.

A report from the Educational Facilities Laboratories, Inc., conveys this graphically:

> ". . . the demographers report that our population will double between 1960 and 2000, with the result that we must build a second America around and above the present one. Note the span of time—40 years to duplicate and serve again what has taken over three centuries to build. This growth provides both challenge and opportunity. The colleges and universities of America face the same challenge and opportunities, but they have only a decade—the 60's—to work it out. The academic population will double not in the next 40 years, but in the next decade. . . ."

The exploding population and the exponential rate at which new knowledge is being generated are complicated by a third factor, namely the changing science and technology of our current society. This creates its own demand for a rapid and economical answer to the problems of education. Professions and vocations in today's world are changed in many important ways during the span of a man's productive years. In the past it was possible for a man to learn a profession or a trade and look forward to a practice without a continuous effort to learn much that was new. Even 50 years ago society accepted as productive and efficient that artisan who continued to work with a particular set of procedures for his entire lifetime. In the world of today, and increasingly in the world of tomorrow, occupational change has become a fact of life. It is no longer possible, in the more highly developed countries, for a professional, technical, or skilled man to stop learning. Moreover the men and women who are learning these professions and vocations are living longer. The increased number of older persons is in itself an additional significant factor increasing the requirement for education. The resources required to cope with resultant critical educational problems, particularly teachers and schools, are not only expensive but also slow in becoming available in the needed numbers.

The impact of machines in industry, agriculture, research, and other fields is well known. Experts feel that machines may make a similar, or greater, impact upon education. The machine makes it possible to accomplish in the absence of a "live teacher" some of the critical functions of instruction through autoinstruction or automated teaching.

Teaching machine technology may be divided into two parts: (1) programmed instruction; and (2) the machine by which the instruction may be presented.

1. Programmed instruction is information broken down into manageable bits and arranged in a logical sequence so that the information may be acquired faster and remembered longer. The "program" refers to the curriculum material or subject matter that is placed on the teaching machine and should be distinguished from a "computer program," which is a set of detailed instructions given to a computer to enable it to perform a given task.
2. The teaching machine is a physical means by which the program is presented and may take the form of a programmed textbook, a simple mechanical device, or a complex electromechanical system involving an electronic computer.

Teaching machines and the instructional programs used in them have developed partly on the basis of a large body of work by psychologists in conducting studies in learning. The machines reflect important principles of effective learning and are designed to present the student with programs of questions and answers, problems to be solved, or exercises to be performed. In addition, they provide some type of automatic feedback or correction to the student so that he is informed immediately of his progress at each step and is given a basis for correcting his errors.

The feedback principle regulating the student's behavior is the common characteristic of teaching machines. This characteristic distinguishes teaching machines from what might be termed "teaching aids" such as films, recordings, closed circuit television, and certain other audio-visual equipment as ordinarily utilized. Specialized educational tasks further challenge the educational specialist.

Dr. Ashcroft has already presented an excellent historical background of the philosophies and movements which relate to teaching machine development and use. I paid great attention to what he had to say, for he touched upon the viewpoints of groups who consider teaching machines limited to little more use than that of "page turners." Divergence of viewpoint is healthy, and in our discussion some of the attitudes are presented of teaching machine proponents who envision a much broader role for their devices and products.

I speak of this topic not because of any expert knowledge in the specific applications of these new methodologies to the blind but rather because, along with my colleagues, I have had some 14 years of "autoinstructional" research experience. This has related to the development of specific kinds of educational systems, integrating and/or developing such autoinstructional educational devices as were pertinent to the educational systems under consideration. Some of the techniques used at the New York Institute of Technology have ranged from systems analysis of our educational procedures, through use of methods and machines as esoteric and involved as teaching by computers, to instruction given with very simple devices.

It is the use, development, and availability of numbers of such devices which lead one to take issue with frequently repeated comments that teaching machine hardware and equipment really are not much more than "page turners." Refutations of these opinions become necessary, for within the teaching machine field there exist wide divergences relating not only to the philosophies of programming instruction materials but with respect to fundamental needs for any teaching machines beyond the simple programmed text.

As mentioned above, neither programmed instruction nor teaching machines are products of this decade. Thorndike and other psychologists in the first decades of the 20th century predicted, almost as if endowed with clairvoyance, the very types of teaching machines that have become so common today. Pressey, as far back as 1915, in his work at Ohio State University, began a determined effort to mechanize both teaching and testing. By the middle of the 1920's he had developed a number of devices which are emulated widely in present day practices. By the early 1930's, Pressey became convinced that his efforts to create a new educational technology were premature and adoption of both philosophy and devices would have to await another decade. At mid-century, the predicted tremendous impetus leading to the present day movements began.

New York Institute of Technology is a senior degree granting institution of higher education and is located in New York City. Much of the research work done at the Institute over the past several years has been concerned with finding directions and techniques which would serve to contribute to solutions of present day educational needs. Thus one direction of fundamental research involves ascertaining basic parameters of the educational processes, relating them to the logistical considerations and the mathematical simulations of teaching systems, and then examining the implications that spring from these analyses. In many cases, the educational process, viewed from the sense of an operation, bears surprising parallels to the structures formed within business and industrial organizations. Administratively the educational organization certainly is no more complex. It appears logical that the techniques of operational analysis, game decision theory, and system methodology used so successfully in management will eventually find wide application in teaching.

An alternate research approach has as its objective the development of low-cost teaching devices useful and readily applicable in varied educational situations. The high initial cost of even relatively unsophisticated equipment is often sufficient to prevent a fair test or adoption of the instrument in the school situation. I should like to mention several typical solutions to this problem.

If you are concerned with practical applications of educational technology (a vital interest of many of the educators working with people who have problems with vision), you may find that some of the hoped for answers may lie, in large part, in extension of present day graphological techniques. Thus, the demands of teachers of the visually handicapped have resulted in advances in paper recordings and tape talking books.

The following items demonstrate some of the potentials inherent in both graphological techniques and adaptive teaching machines:*

1. A scroll with nonrepetitive printing on a nonseamed continuous strip
2. A lowcost housing for scroll with masking device**
3. The Colortutor process: preprinted test sheets for multiple choice and linear programmed use**
4. An anthropomorphic Variable Sequence Automated Teaching Device (an abstract taken from the tape recording included in this device follows here).

"This machine is operated by a computer. When you sit at the console the machine will explain its own functions, and since technology is capable of such wonders, why don't I stop and let you hear what a person who seats himself at the console hears from this machine as it begins:

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* A number of the devices referred to here are illustrated at the Institute for Instructional Improvement, Inc., 110 East 30 Street, New York 16, N. Y.

** Available through Educational Aids Publishing Company, Carle Place Post Office, Long Island, N. Y.

" 'Hello. May I introduce myself? I'm called ATD-Primus, a short way of saying that I'm an early prototype of an automatic teaching device. My job is to work with the teacher and relieve him of many of the routine functions of teaching, from the recording of grades to the presentation of curriculum materials. By helping to teach the student, either individually or in a group, by recording test scores automatically, I can free the human teacher, allow him to utilize his gifts of personality, experience, and knowledge to the fullest advantage. Now before I explain to you how this is to be done, I just want to remind you that my human designers have given me a number of interesting features. For instance, I never get tired or forgetful; I can repeat whatever information is fed into my memory whenever someone asks for it. I like to talk as I'm doing now. I can be stirring (dramatic music); if you prefer, I can present the "greats" in dramatic roles (presentation of Hamlet's soliloquy); or the finest in music (musical interlude). Whatever limitations I have are those imposed upon me by my human masters.

" 'Now let me explain how I function technically. With your assistance I'll actually show you how I might teach a sample lesson. . . .'

"The operation of this device is typical of an adaptive machine. As the student works, the machine presents information and adjusts its program, presenting different concepts and different materials to the student as he needs them."

5. Automatic data gathering and testing device
6. Mechanical, electronic, and electromechanical "lead-out" sensing instrumentation (including audio)
7. Tactile teaching machine systems
8. Comparator adaptive systems
9. Film sequences of present day types of teaching machines.

The history of the teaching machine movement is a measure of efforts to increase the degree of interaction within the learning process. In all of the devices that have been demonstrated the effectiveness of the machine has a direct relationship to the feedback it can provide. The success of hardware is contingent on its ability to provide necessary adaptability and responsiveness to the individual needs of the student.

Sufficient strength of the program content is, of course, a requisite. Then, refined devices such as the computer will provide the highly individualized instruction and complete flexibility of branching to achieve fully automated instruction and maximum benefits of the skill of the human teacher. This is the promise of the future.

REFERENCES

1. Stolurow, Lawrence M., *Teaching By Machine,* U. S. Department of Health, Education and Welfare, Office of Education, Cooperative Research Monograph No. 6. Washington, D. C.: Superintendent of Documents, Government Printing Office, 1961.

Additional References

An Automated Teaching System, a Teaching Machine, and Programmed Learning, Organized and Designed by Members of the Staff of New York Institute of Technology, Institute for Instructional Improvement, Inc., 110 East 30 Street, New York 16, New York.

Coulson, John E., (ed.) *Programmed Learning and Computer-Based Instruction.* New York: J. Wiley, 1961.

Review of Educational Research, American Educational Research Association, Volume XXXII, No. 2, April 1962.

SECTION II

VOCATIONAL AIDS

CHAIRMAN: ARTHUR L. VOORHEES
American Foundation for the Blind, New York, New York

THE OFFICE OF VOCATIONAL REHABILITATION VIEWPOINT AND ROLE IN DEVELOPMENT OF ADAPTED DEVICES

LOUIS H. RIVES, JR.
Office of Vocational Rehabilitation, Department of Health, Education, and Welfare, Washington, D. C.

The Office of Vocational Rehabilitation (OVR), which I represent, is happy to have had a part in making this Congress possible for we know that the information coming out of this meeting, as well as the new ideas which will be stimulated here, will enable us all to do a better job of vocational rehabilitation. My remarks will be rather brief, but I do want to tell you a little about the functions and responsibilities of OVR and of our interest in the sponsorship of research activities.

In 1954, OVR was given legal authority to make grants supporting research to find better methods and techniques for rehabilitation of handicapped persons, to conduct demonstrations on how these techniques and methods should be carried out; and, equally as important, to support the training of personnel in colleges and universities in the many skills and disciplines required in serving handicapped persons. In our research and demonstration program since 1954, we have supported about 70 projects relating directly to the rehabilitation of the blind at a cost of approximately $2 million in federal funds. Perhaps a few examples will tend to illustrate the sort of things we have been supporting. One is the research program at Massachusetts Institute of Technology (MIT). We have great hopes that through bringing to bear on the problems of blindness the immense scientific resources of this great Institute, we can begin to find some better answers to the problems of communication, of mobility, and orientation. We also hope that the ideas in the research of blindness which are generated at MIT will spread to other research facilities so that knowledge about their interest in research relating to blindness will permeate the whole research community. We have already seen one interesting result. A young scientist, who became interested while studying at MIT in a device to warn blind persons that they were approaching an object, has now moved on to Stanford University where he is undertaking research to perfect this warning system. Another example of our research interest is in the field of how blind persons use their hearing and how its use may be improved. In this area, research has been done by the Industrial Home for the Blind, the Cleveland Society for the Blind, and by the C. W. Shilling Laboratories. We have, for example, learned that in some cases the use of a binaural hearing aid can substantially improve the travel ability of some hard of hearing blind people.

Another area in which we have supported research is in learning through touch. Through grants to the American Printing House for the Blind, we are exploring the most effective ways of presenting diagrams, maps, charts, etc., to blind people. We have also supported research relating to the attitudes of the sighted population toward blindness, and of blind persons toward the sighted population. We feel that an understanding of these attitudes can lead to their modification in order to facilitate the acceptance of blind persons into employment as well as other normal community activities. This research has been done at Columbia University and at the University of Pittsburgh. Another interesting research project in the area of attitudes has been conducted at the Georgetown University Medical School, in which we are attempting to teach resident ophthalmologists about blindness. We have no doubt that our ophthalmologists are second to none in the matter of saving sight, but we feel that it is most important they also become familiar with the problems encountered by their patients when sight is lost. If the ophthalmologist is informed about the services available to blind persons and the results in independent living and self-support which blind people can achieve through using these services, he can help breach the gap for his patient during the period of adjustment and thus greatly facilitate the rehabilitation process.

Research has also been sponsored by OVR to help improve the quality of personnel engaged in work with the blind. A grant for this purpose to the American Foundation for the Blind resulted in a study of the compensations, qualifications, and types of personnel currently employed in the field which, in turn, led to another grant to establish a national personnel referral service at the Foundation through which we hope to attract high caliber personnel into our field of work. Research has also been sponsored at many institutions, such as the Illinois Institute of Technology, Duke University, Purdue University, and Perkins School for the Blind, in the whole area of the psychological testing of blind persons. Our goal here is to make sure that our tools for measuring the skills, aptitudes, and personality factors of blind persons are as good as those used for the general population.

There is just one other project which I wish to mention. This has been a research project in the area of training blind persons to become Russian language translators. It is going on at the Georgetown University School of Linguistics under the direction of the world famous Dr. Leon Dostert. In the first two years of this project, 15 blind students have been trained to translate oral Russian into written English. The techniques devised and the results obtained have convinced us that it is entirely feasible to train blind persons as translators, a field wherein there is a major shortage in this country. Our experience has also indicated that techniques can be developed through which blind students may teach sighted classes in foreign languages. The project was expanded in September of 1962 to include 30 new students who are being trained—some in Russian and some in German—to be both translators and teachers. Through this project we hope to open up a substantial employment opportunity for blind persons.

Now, just a word about our demonstration program. Through it we attempt to put into practice the things we learn through research. One excellent example is the optical aids or low vision clinics. It was learned through experience at the Industrial Home for the Blind, the Pennsylvania Working Home for the Blind, and elsewhere, that through the proper and careful fitting of special optical aids and through the proper training in their use, many persons with very low residual vision could be substantially helped. Of course, they could not be restored to 20/20 vision, but their vision for specific purposes could be vastly improved so as to enable them to perform certain occupations as sighted persons. Although this knowledge was generally available, it was not being put to use, so we developed what we call a prototype project. This project involved the most effective features relating to the operation of an optical aids clinic. Then we offered to support applicants who would follow this prototype project in establishing clinics throughout the country. To date, we have established about 20 optical aids clinics that have proved so successful that many, many more have been established without federal financial support. We hope to apply the same demonstration techniques to other ideas developed through research.

As I mentioned earlier, another equally interesting aspect of our work in the OVR is the program for training personnel conducted by OVR grants to colleges and universities, and other training facilities. For a long time, we have known that there are special techniques that are effective in placing blind persons in competitive employment. These techniques have been developed by such pioneers as Mr. Joseph Clunk and Mr. John McAulay and refined by experts, such as Mr. Arthur Voorhees and Dr. Douglas C. MacFarland. But they must be passed on to the new personnel coming into the placement field, and they must be constantly evaluated and improved. To do this, we support a training program at Southern Illinois University where, three times a year, some 10 to 20 counselors are given concentrated instruction and field work in the placement of blind persons in competitive employment. Also, as an integral part of this course, the same counselors are given a one-week follow-up course, in their own areas of the country, within six months to a year after they have completed the course at Southern Illinois University. Through this follow-up, the effectiveness of the course is evaluated and necessary changes are constantly made to keep abreast of technological changes in the employment field. A similar course was conducted in professional placement based on a study done by Dr. Norman M. Yoder, which will be described in a later paper.

We are also undertaking programs to train personnel in the best methods and techniques for placing blind persons in agricultural pursuits. This course is given periodically at Kansas State University. Currently the curriculum is undergoing a complete re-evaluation since we have found that the whole agricultural economy has changed so much during the last 15 years that the techniques which we developed then may no longer be valid. We want to be sure that, when we rehabilitate a person into an agricultural job, it will not be one which is no longer economically sound. This points up, I think, the need for constant study of our techniques to make sure that what we are doing for a rehabilitation client takes into account the best knowledge available.

Another area in which we support training is in the field of mobility.

We know that with proper training in cane technique most blind people can learn to travel efficiently and safely. Up until now, there has been a great shortage in skilled and competent instructors. We have, therefore, initiated two programs—one at Boston College and one at Western Michigan University—through which competent instructors will be trained. These programs are at the Masters Degree level and presently are turning out about 25 instructors each year. We try to make training available wherever it is needed for personnel involved in the entire rehabilitation process which, of course, includes all the diagnostic procedures; medical restoration, where possible; and the whole adjustment process to blindness which, I think, is the most important of all. This adjustment process, as we see it, includes very briefly, mobility; adequacy in the demands of daily living, including table etiquette, dressing, etc.; communication skills sufficient to keep records and to write to other people; a recognition of the fact that in some areas sighted assistance is essential, skill in getting this assistance when it is needed and in getting rid of it when its purpose has been served. After the adjustment process, there is the matter of prevocational and vocational training; and, of course, the end result, finding the proper job and succeeding in it. That final aspect of the rehabilitation process, that of placement, is the one with which we are most closely concerned, for many of the following chapters relate to devices which assist blind persons in performing jobs. You may want to keep in mind, therefore, some problems identified by placement people which still await solution, so that additional numbers of blind persons can find jobs. These are:

1. A good safe effective way for blind persons to solder
2. A good means for totally blind persons to do gluing operations
3. A good compass
4. An efficient, accurate, and reliable level
5. A collapsible cane that does not collapse when you do not want it to
6. A centering device
7. A good handsaw guide
8. In the field of agriculture, a device through which a blind person can candle eggs.

Generally, we want to help wherever possible in developing practical adaptable devices which fill real needs and which are designed to assist the user rather than to delight the inventor. We believe strongly, however, that wherever possible the development of proper methods and techniques is preferable to gadgetry. We also recognize that, perhaps in marginal cases where the blind person is not capable of learning techniques and methods for performing particular tasks, appropriate adapted devices may be a very valuable placement aid. This, I think, is most important because we must assume our responsibility for placing blind persons with multiple disabilities or who may lack the dexterity to perform complicated operations.

I think you can infer, from my remarks, that we are interested primarily in applied research. Our goal is to provide practical means which enable blind persons to do a job which otherwise requires vision.

WOODWORKING PRACTICES AND DEVICES

JOSEPH F. CLUNK
Enterprises for the Blind, Inc., Camden, New Jersey

It is ordinarily assumed that the duties and functions of daily life require, if not normal vision, at least functional vision. The blind person must adjust to a sighted world, and the maintenance of his self-esteem requires him to participate in the same duties and functions as his sighted neighbor, to the extent his intelligence will permit. Very few self-respecting individuals want to apologize constantly for their lack of achievement, and do not want to use blindness as an excuse.

The larger portion of our energies in daily living is probably expended in performing personal tasks close at hand. A blinded person of a certain intelligence and education experiences little embarrassment or difficulty in mental competition with sighted persons of equal ability, but the performance of physical acts, particularly in the field of mechanics or home duties or in recreation, presents problems which cause the blind person either to withdraw from competition or to apologize for inferior results.

Recognition of this need for the maintenance of self-esteem results in much discussion about the need of blind persons for devices that will enable them to perform a task with results equivalent to those of the sighted, and for which no apology is necessary. Many persons have wrestled with this problem. Some have been content to modify tools or instruments used by the sighted, and some blind persons have made devices for their own particular needs without making them available to other blind persons.

The Office of Vocational Rehabilitation decided that a definite effort should be made in behalf of blind persons needing such devices, and accordingly awarded a three year contract to the Maryland Workshop for the Blind, Baltimore, Maryland, on July 1, 1960.

The purpose of the project is to develop mechanical devices and make them available to blind persons at the lowest possible cost, and, at the same time, cooperating with agencies concerned with electronics and with the specialized skills that blind persons must acquire in the use of tools.

The project authorizes expenditures for a part-time consultant, an engineer, and a mechanic, and for the purchase of materials.

Because of the experimental character of this project, it was agreed that full-time personnel would not be employed the first two or three years, and accordingly arrangements were made with two mechanical engineers, and a thoroughly competent machinist, who joined with the consultant in serving the project on a part-time basis. The consultant is the only blind person on the team, and he brings 43 years of experience with blind persons to this project. These persons were selected not only because of their individual skills, but also because they are intensely interested in making a practical contribution to the welfare of blind persons.

When this team requires experience and skill from outside their respective fields, other persons with demonstrated abilities are consulted and asked to make their contributions to a particular problem.

SEARCH FOR PROBLEMS

This project has been explained, the principles outlined in articles published in braille magazines, and blind persons have been invited to submit their problems as well as their own suggestions regarding devices they have designed.

The response has not been up to expectations, although some interesting individual problems have been presented as well as some of a general character. It is more than likely that sufficient publicity has not been given this project, and it is also quite possible that blind persons are discouraged from submitting their problems to an organization because of past experience in which either their requests have been ignored or there have been endless delays in providing the device.

The confidence of blind persons in this and similar projects will be established when they can receive practical devices at reasonable prices. Thus persons who have developed their own devices will be encouraged to make them available through this project to other blind persons all over the world.

TYPES OF PROBLEMS

The average sighted mechanic can find a commercial tool that will enable him to achieve results in any phase of the fabrication of wood or metal. When these tools are too expensive or complicated for personal ownership, the sighted craftsman usually has access to the equipment in a manufacturing plant or research laboratory. The average blind craftsman has neither access to nor the funds to buy such equipment, and must therefore depend on a sighted friend, or spend considerable time in a laborious procedure, or do without it entirely.

There is considerable demand for a mechanical or electrical level that will take the place of the spirit level ordinarily used by carpenters.

The usual doweling jig used by sighted persons is not satisfactory. Although there are several different methods for joining narrow boards together, such as tongue and groove, splines, and edge-to-edge gluing, the use of doweling pins is most popular, and a practical doweling jig is very much in demand.

The approximate centering of wood or metal that is to be turned on a lathe can be done reasonably well without sight, but because of the time involved, a practical device for exact centering is in demand.

Sharpening blades for power joiners and planers, hand planes, lathe turning chisels and similar tools, present a real problem to any craftsman, and the blind person has more than the usual difficulty. Thus a device for this purpose is essential to the blind craftsman.

When narrow boards are joined together to form a wide board, it is necessary to remove high places either by putting the assembled board through a large thickness planer or by many hours of scraping and hand sanding. Because the large thickness planer is very expensive and requires considerable space, an inexpensive, compact device is required that will perform this leveling process in a reasonable length of time. Furthermore it should not rough up the surface of the board when going against the grain of a piece whose grain runs counter to that of an adjoining piece.

Because it is customary for the legs of a table to be reasonably similar, and because customers often want pairs of lamps, candle sticks, fruit bowls, etc., the craftsman making these articles on a wood turning lathe must possess enough skill to make duplicate turnings. If he lacks both skill and sight, he requires a device that will assist him in making turnings that are reasonably similar and for which he does not have to apologize. Various types of duplicating devices are used by sighted craftsmen, but these are not practical for the blind operator of a turning lathe.

The measurement of materials presents a real problem for many blind craftsmen, and special devices or special adaptations of the standard rulers are very much desired. Although approximate measurement is apparently satisfactory for some craftsmen, there are many who desire the same exactness as sighted mechanics. Many efforts have been made to adapt a micrometer so that a blind craftsman can make close measurements, but up to the present time a really satisfactory instrument for the average blind person has not been designed.

Practical thermometers are required for the use of blind persons employed in the photographic industry.

Meter-reading devices are desired by blind persons who often find it necessary to call upon sighted friends or associates to read a voltmeter or ammeter.

When blind persons use magnetic recording machines involving spools of tape or wire, they have difficulty in determining when the end of the tape or wire is reached, and as a result they must stop the machine frequently during the last few minutes of operation. A device is necessary that will give a blind person a signal before the end of the wire or tape is reached.

A blind typist apparently needs two devices. One is a device that will enable him to correct his own typographical errors, and the other is a warning device to indicate when the last two or three lines at the bottom of the page are reached. This is a special problem when the typist is using a dictating machine and both ears are occupied with the headset.

A blind person living in a rural area requested a device that would enable him to find the gate of his yard when he returned from a visit with a neighbor, and to find the gate when shoveling snow from the front door of his house to the highway. A sound beacon of some kind would seem to be necessary for a person living under these conditions, not only to locate his own home but also, perhaps, the barn and live stock enclosures. Electrical devices of various kinds could be made available, but even the supply of electric power to them is not always convenient.

Apparently housewives have some problems in the preparation of food, and because some wish to reduce their dependency on sighted members of the family, devices are needed that will reduce this dependency.

A mechanic working with metals in the repairing of appliances, or in making articles involving metal parts, has need for practical soldering and welding devices.

The usual braille stylus is not satisfactory for the blind person who must write braille by hand for three hours or more at a time, because a great deal of muscle fatigue develops in the hand and forearm. This problem is experienced by students taking notes in class or persons in professional fields where they must make voluminous notes.

Undoubtedly there are many other problems for which devices would be welcome when they are developed, provided they are available at reasonable prices and are of such design that a person of average skill can use them satisfactorily after the loss of sight.

DEVELOPMENT PROCEDURES

Weekly staff conferences are held when a particular device is being developed. Suggestions from blind persons are reviewed and the staff agrees on a preliminary design for the device. When the engineer has completed the first drawing, conferences are held and designs are either changed or approved after everyone has had an opportunity to review thoroughly all suggestions. The machinist is then authorized to make the first prototype, and problems encountered in the production of the prototype are reviewed in conference. The device is then presented to the staff, and evaluation tests begin. As a result of these tests, modifications and changes are made and tests continue. Further prototypes may be made incorporating such changes as experience dictates, either for greater accuracy, to reduce cost of production, or to make the article more rugged.

DEVICES IN DEVELOPMENT

One prototype of a mechanical level is made by calibrating a disc or dial every 15 degrees (see Figure 1). This dial is fastened at the center of a

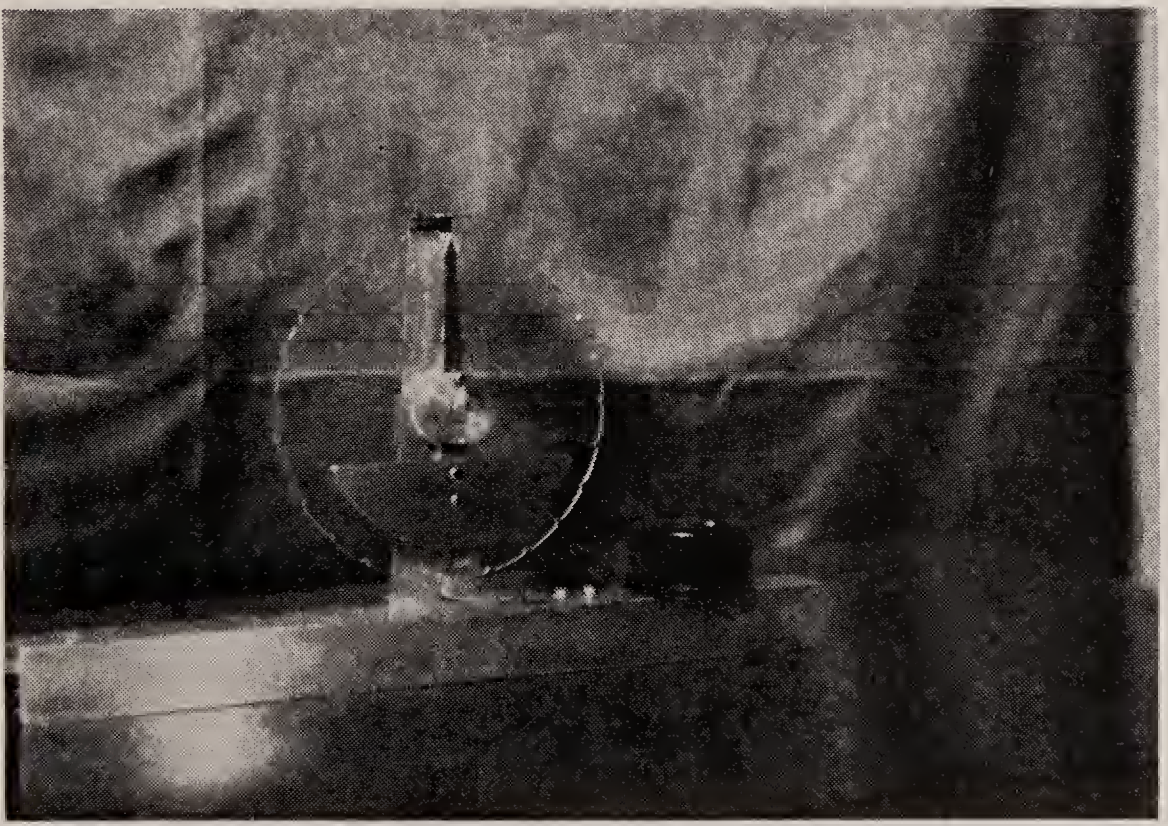

FIGURE 1 Electromechanical Level

bar of metal 12 inches long, 1 inch wide and $\frac{1}{2}$ inch thick, and the dial is at right angles to the 1-inch face. The housing for the shaft consists of a piece of $\frac{1}{2}$-inch tubing fastened to the center of the dial. This tubing is fitted with a rod approximately $1\frac{1}{4}$ inches long with a machine nut at the back end. A $\frac{3}{16}$-inch rod is inserted through the dial, and into the center of the rod. The weighted pointer is placed on this rod so that it turns freely. The blind person can determine the angle by touching the pointer without disturbing the reading, since once the weighted pointer comes to rest, it is locked in position by tightening the nut in back of the dial. If the material is not perfectly level, or is not at the angle desired by the craftsman, the lock nut is loosened, the material adjusted, and another reading taken in the same manner. This instrument can be used in any position, and zero can be established on the dial at each of the four quarters as at positions 3, 6, 9, and 12 o'clock on the dial of a watch.

Another prototype of mechanical level is made by suspending a pendulum from a point 8 inches to 10 inches above the base. This instrument can only be used on the surface of an object in the plane of the horizon and cannot be used on vertical surfaces or angles between vertical and horizontal.

One prototype of an electric level is made by wiring each of the calibrated points of the dial as well as the pointer. The desired dial reading is energized by a moving contact at the back of the dial. When the level is placed on the material to be measured, the pointer comes to rest on the energized contact points and a buzzer rings, indicating to the craftsman that he has achieved the desired angle. This procedure presents a number of problems in the energizing of the various calibrated points and the pointer, as well as in the friction developed at the contact points which prevents exact readings.

Another electric level using the pendulum principle is under construction. A buzzer will sound except when the indicator is in perfect center. The angle will be established by using a calibrated dial base. Thus when the craftsman wishes to set the pitch of a roof of his building at 15 degrees, he will lock the dial at 15 degrees, and the pendulum will be silent when the rafter is at the desired angle. This instrument will be usable in any position except upside down.

A third electric level is being developed in which mercury is enclosed in a glass vial with electric contacts fused in the glass. When the instrument is at the desired angle, a buzzer will be sounded.

A self-centering and self-aligning doweling jig has been completed (see Figure 2). This enables the craftsman to drill dowel pin holes exactly in the center of the narrow edge of a board, and to space them uniformly along the length of the board. It consists of a bar of steel 1¼ inches thick, 2 inches wide, and 8 inches long. The bar is placed on edge and two holes are drilled in the center of the 1¼-inch face, 2 inches from each end of the bar. These holes are ¾ inch in diameter, and are fitted with hardened, self-locking drill bushings which may have any desired inside diameter. A slot is cut on the edge of the bar underneath the bottom of the drill bushing.

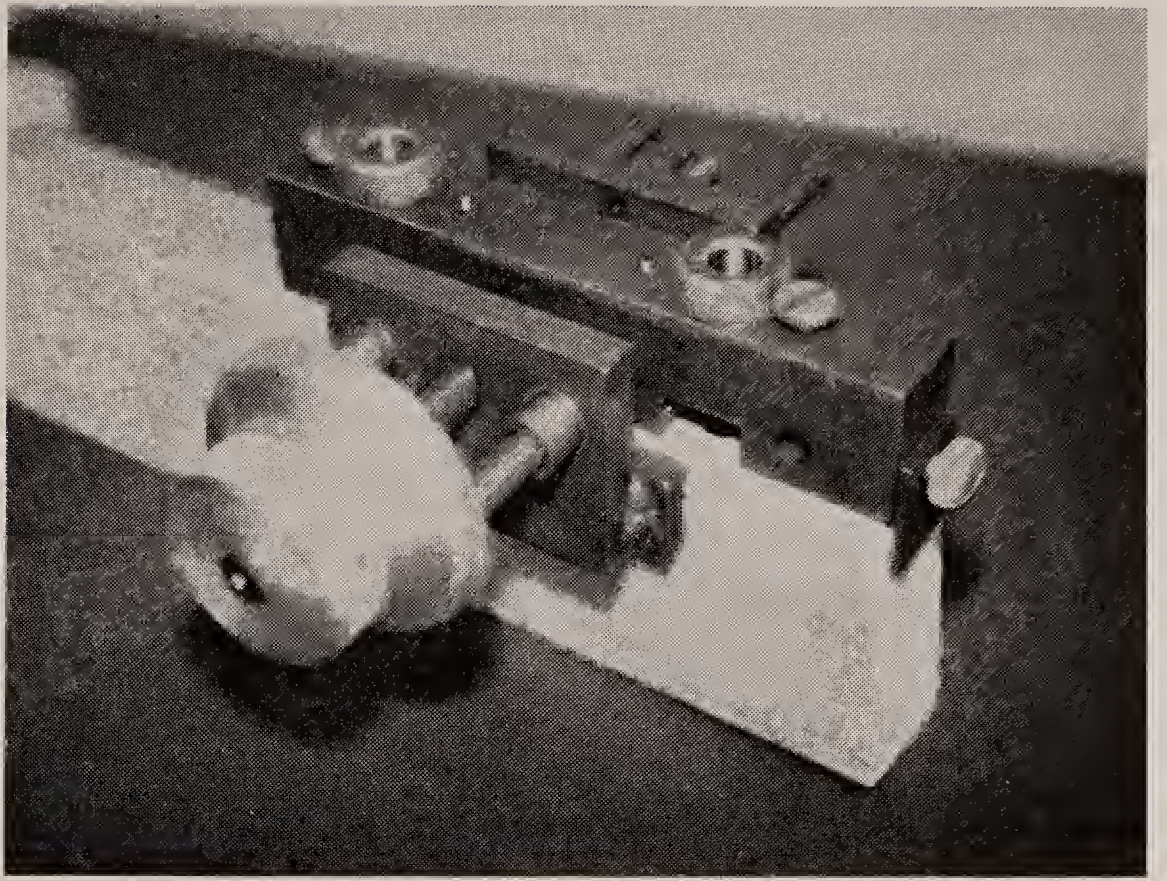

FIGURE 2 Doweling Jig in Position for Drilling First Two Holes

This slot is a quarter-inch deep and $\frac{3}{4}$ inch wide, and permits wood chips to be discharged without jamming the drill. A threaded bar of half-inch steel is inserted at the center of the steel block and held in position with a locking setscrew. This bar has a right-hand thread on one end, and a left-hand thread on the other. A shoe or clamp is attached on each end of this bar by using tapped bushings, one with a right-hand thread, and the other with a left-hand thread. These steel shoes are 4 inches long and 3 inches high. Each shoe or clamp has an offset at the bottom which permits these two clamps to come together underneath the bar when the threaded screw is turned. Two steel guide rods fitted with slide bearings are placed parallel to the threaded bar, and $1\frac{1}{2}$ inch each side of center. A piece of metal is hinged at the right-hand end of the 8-inch bar, and this is dropped down and fastened with a thumb screw so as to provide a stop at the end of the board to be doweled. A spacing arm is hinged to the main bar, and fitted with a plug, which has been turned down in stages so that it has $\frac{1}{4}$-inch, $\frac{5}{16}$-inch, $\frac{3}{8}$-inch, and $\frac{1}{2}$-inch diameters. When using this device, the craftsman clamps the board on edge in a vice. The jig is then placed on the edge in which he wishes to place the dowel pins. The hinged piece at the right-hand end of the jig is dropped down so that it will come against the end of the board when the jig is in position. Turning the threaded bar draws the shoes toward each other against the side of the board, and clamps the doweling jig on the edge of the board. Two holes are then drilled in the exact center of the edge of the board exactly 4 inches apart for the depth desired by the craftsman. The clamps are then released, the end wing lifted out of position, and the jig moved lengthwise along the board. The location pin is then placed in the last drilled hole, and clamps are again tightened on the sides of the board. Two more holes are drilled, and by following this procedure, dowel pin holes are placed 4 inches apart and exactly centered on the length of the board. The second and subsequent boards are drilled in exactly the same manner. It is unnecessary for the boards to be exactly the same length, for after they have been joined, they can be trimmed in the usual manner.

Several prototypes of a centering jig have been made, but the most satisfactory one consists of the following (see Figure 3). A round metal box is made by cutting a ¾-inch piece of a 2¼-inch bar of steel or aluminum. Two parallel slots are milled ¼ inch deep, ¼ inch wide, and 1 inch apart across the flat, 3-inch surface on one side of this block. A round recess is cut into this side of the block so as to permit the insertion of a round gear that will mesh into the sides of two ¼-inch square rack gears, one of which is placed in each of the two slots. Another segment of the 2¼-inch bar, approximately ⅜ inch thick, is used as a cap or lid on the other segment, and is attached by means of two machine screws. A center hole through the entire assembly permits the fitting of a captive punch, approximately 2 inches long and of quarter-inch diameter. The rack gears can be of any length. One end of each of these rack gears is fitted with an offset V-block

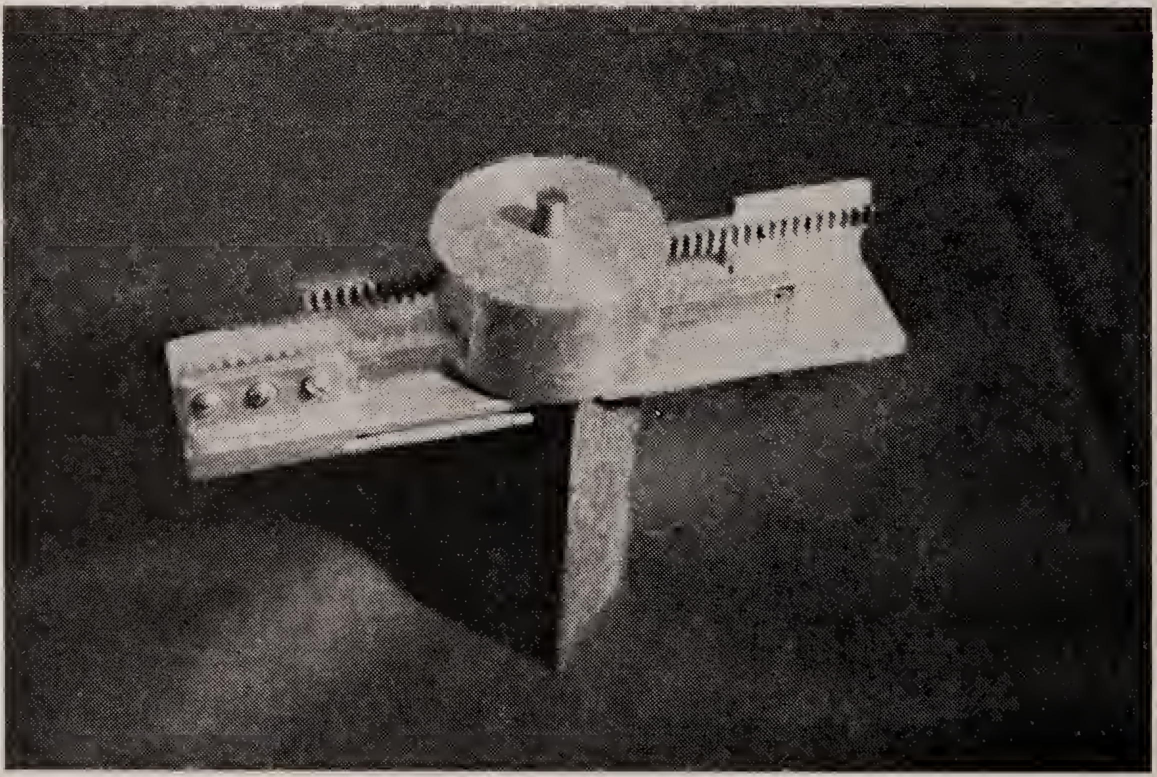

FIGURE 3 Centering Device Ready to Use

in such a manner as to have the bottom of the V-block come exactly against the center punch when moved into position underneath the center box assembly. Moving one of these rack gears across from left to right will simultaneously move the second rack gear from right to left. One of the teeth at the end of the rack gears is peaned over just enough to keep it from passing the round center gear. In using this device the craftsman clamps his piece of wood or metal in a vertical position in a vise, placing the round box on the top end of the material, and moves the V-blocks into contact. A thumbscrew placed in one side of the box enables the craftsman to lock the rack gears so they will not move. The center punch is hit with a hammer, and the craftsman can then drill a small center hole at this point in the usual manner. The craftsman is able to center a piece of material perfectly in about one-tenth of the time required by available commercial tools.

The average craftsman working with wood has joiners 4 to 6 inches in width, and frequently has a thickness planer up to 12 inches in width. Hand plane blades are of various widths up to $2\frac{1}{2}$ inches, and many lathe chisels have set edges, and are from $\frac{1}{8}$ inch up to $1\frac{1}{2}$ inches in width. This device enables the craftsman to sharpen these tools perfectly (see Figure 4). It consists of a clamp 12 inches long, 4 inches wide, and two jaws, each of which is $\frac{3}{8}$ inch thick. The lower jaw has a milled space at the center at right angles to the length which permits hand planer blades and flat chisels to be clamped at the desired angle to the base of the grinding wheel. Planer

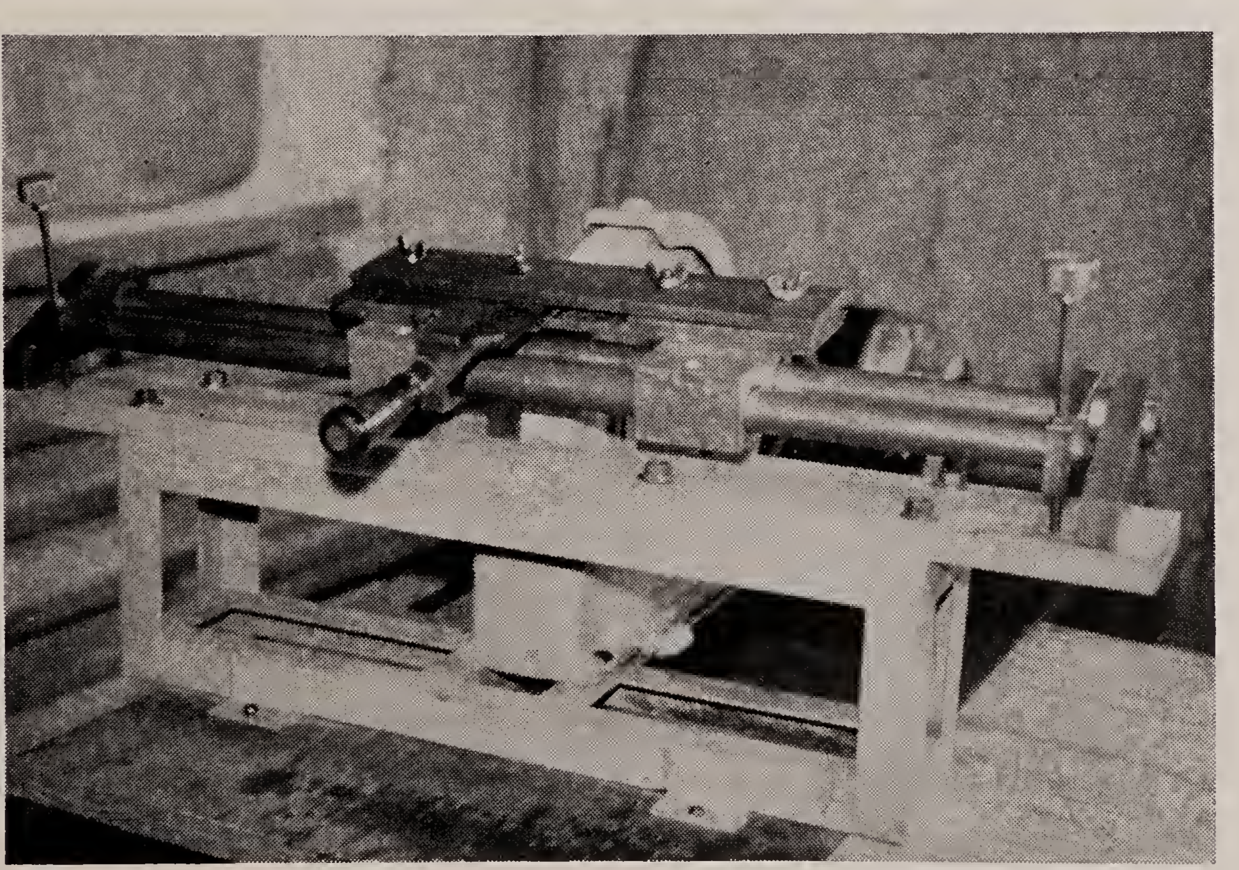

FIGURE 4 Device for Sharpening Planer Blades and Chisels

and joiner blades up to 12 inches in length are held between the jaws of the clamp by means of four bolts and wing nuts. Adjustment for planer blades is secured by using a spacer between the back of the blade and the back of the lower jaw, parallel to the front of the clamp. This clamp is fitted with a V-block on the under side which rides on a 1-inch round steel bar, and the back of the clamp is hinged to another round steel bar parallel to the front bar about 3 inches from it. These are 25 inches in length, and the front one is fastened solidly in each end of the jig framework. The second parallel bar is hinged to the front bar by means of a steel plate at each end. A long threaded bolt is fitted at the hinge at each end of the back rod, and provides for the raising and lowering of the back rod. This brings the front edge of the clamp in contact with the face of the grinding wheel. When the craftsman wishes to sharpen a planer blade of any length up to 12 inches, he simply clamps it in position, adjusts the threaded bolts at each end of the device so as to bring the blade in contact with the face of the grinding wheel, and then moves the entire clamp assembly slowly from end to end on the parallel rods while the grinding wheel is turning.

A second prototype has been made and is quite satisfactory except that it is too heavy, and when put in production it will be made of lighter and stronger materials.

In order to avoid chipping the grain on the surface of joined boards whose grains do not run in the same direction, a sanding machine has been designed, using the same principle as a thickness planer. The machine consists of a drum 6 inches in diameter and 28 inches long, suspended in ball-bearing pillow blocks in the top of a framework 36 inches long, 24 inches wide and 40 inches high. This steel framework is fitted with 2-inch swivel casters. The platform or base is raised and lowered underneath this drum by means of gears similar to those used in a thickness planer, and a 1 hp motor is fitted on a hinged base at the bottom of the framework. The drum has a quarter-inch felt covering to provide a cushion for the sandpaper. Sandpaper or similar abrasive material is fitted on the drum for a length of 24 inches. After the craftsman has joined narrow boards together by doweling or some other method, and after the glue is dry, he can place this assembled board on the platform underneath the drum and raise the platform until the board comes in good contact with the lower side of the drum. The board is pushed by hand against the direction of travel of the drum, and thus the high spots are ground off. If the board is more than 24 inches wide, but not over 30 inches, the entire surface is treated by turning the board around and having the sanding areas overlap. After one side is sanded, the process is repeated for the other side. The sandpaper does not chip the surface of the boards in the same manner as the blades of a planing machine. The platform is raised as much as is necessary to secure the desired leveling result. When not in use this machine can easily be moved and stored in an inactive area of the hobby shop. This machine can be made available to the blind craftsman for approximately one-fifth of the cost of the thickness planer of equal capacity.

A lathe duplicating device has been designed, but the prototype is not yet completed. It will consist of a framework equipped with roller-bearing carriage that will run lengthwise with the lathe in a controlled channel under the bed of the lathe. This assembly will be fitted with a shaft which will slide back and forth at right angles to the travel of the lathe. The shaft is bent at right angles, and comes from underneath, and in front of the bed of the lathe to a point where a pivoted tool holder brings a cutting tool in line with the center point of the lathe. A bracket at the back of the lathe headstock, and an adjustable bracket at the other end of the framework simulates the movable tail stock of the lathe. The pivoted tool holder will have a vertical extension with another tool holder at the top, and this is in line with the center of the upper bracket. When the craftsman has turned one table leg or lamp stem, he will place it in the holder immediately above the lathe and fasten it securely. The tracing tool will then be adjusted so that it will follow the pattern of the first turning, and will compel the cutting chisel in the tool rest to duplicate this first turning. The craftsman controls the cutting chisel by manual operation. Duplicate faceplate turnings will be made by fitting the faceplate on the upper holder immediately above the faceplate on the headstock of the lathe. The chisel holder is pivoted so as to give the craftsman as much flexibility as though it were completely free hand.

Two prototypes of an end-of-tape signaling device (see Figure 5) have been made; a third is being developed. This design provides for contact with the tape on the spool by a roller bearing on the end of a pivoted arm. The pressure of the roller on the bearing against the tape cannot exceed $\frac{1}{2}$ ounce regardless of the diameter of the tape spool. Pivoted arm contact is maintained by a clock spring. The device is calibrated to indicate the setting for the diameter of each of the three most commonly used spools of tape, namely 2 inches, 5 inches, and 7 inches. The operator sets the device for the particular size spool, and after placing the empty spool on the spindle, he brings the contact roller to approximately $\frac{1}{8}$ inch from the hub of the spool and locks the device in position. The empty spool is then replaced

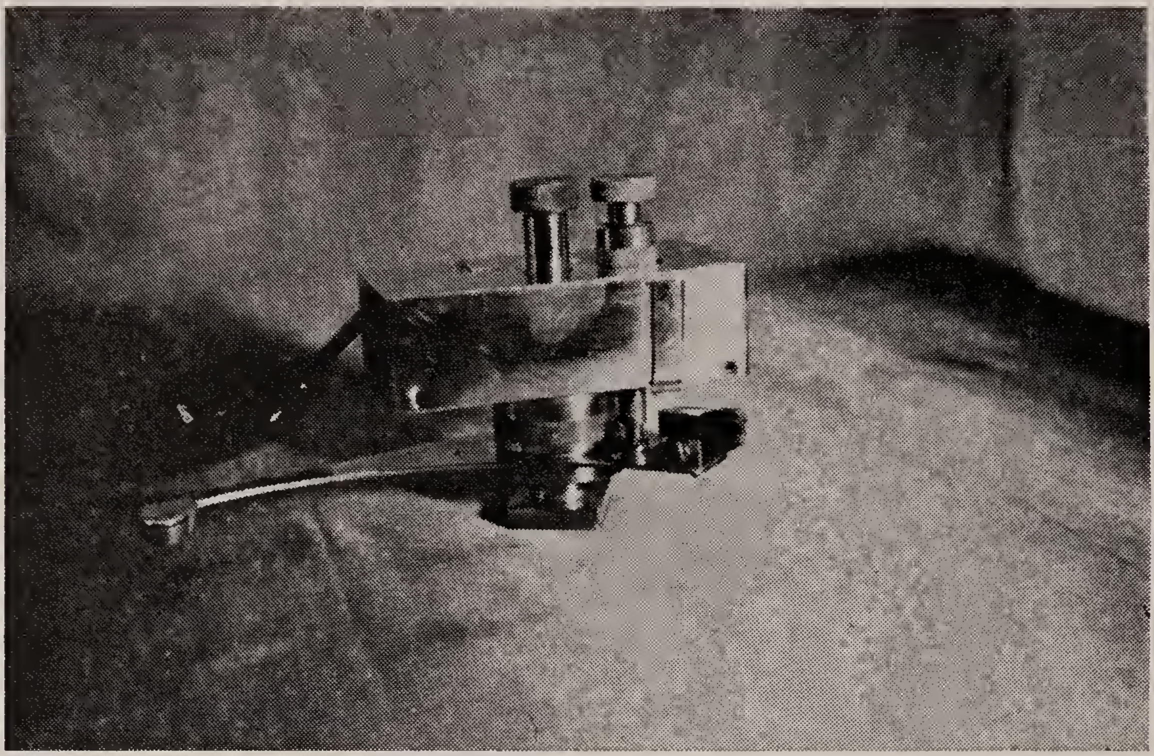

FIGURE 5 Signal Device for Tape Recorder Ready to Mount

with the same size spool filled with tape, and the roller is permitted to ride on the tape as the recording is being made. When there is approximately $\frac{1}{8}$ inch of tape remaining on the spool, a microswitch in the device rings a buzzer, informing the operator that the tape is nearly finished. The arm can be swung out of position and locked when the operator does not want to use it. This device has a bracket which permits adjustment vertically and horizontally, so that it will fit on the case of the average recording machine regardless of brand and size. It is necessary, however, that the spools of tape not be recessed in the deck of the recording machine.

A blind man, in wanting to help his blind wife (a dictaphone typist) in the problem of correcting typographical errors, has developed an erasing guide that she has found very practical. It consists of a piece of metal approximately $1\frac{1}{2}$ inches square, bent in a curve so as to fit the roller of the typewriter, and it is attached to the body of the machine so that it comes into position four lines above the key contact point on the roller. An opening is cut in the metal shield which exposes four letters. When the typist wishes to erase an error, the carriage is backed up to the spot where the error occurred and the roller is turned up four spaces, placing the erroneous typing in the opening of the shield. The typist makes the erasure, lifts the shield out of position, pulls the first sheet forward and drops the shield into position again to erase the carbon copy. The material is then returned to position and the correction made in the usual manner. A device to give the typist an end-of-page signal has not yet been made but is under consideration.

There is at least one electrically operated sound beacon that has been developed for use in rural areas, but it is not in production. The cost of this equipment is prohibitive for the average blind person and the maintenance cost of batteries is also a problem. It is not always convenient for an electrically operated instrument to be wired to the electric service on the farm. A mechanical beacon device has been designed that operates on the principle of a small windmill. The shaft in this windmill will have an extension that will ring a bell every time it revolves. This device presents some problems in the matter of protection from the weather, and the certainty of operation in the mildest weather. Obviously the most sensitive windmill cannot make a noise if there is insufficient air to make it turn. This device should be inexpensive and easy to install. Experiments have been made with glass chimes, which make a noise in even the slightest movement of air, but the signal is not loud enough. Experiments will be conducted with other mechanical and electrical devices until an answer is found.

A welding rod has been found which enables a sighted welder to maintain the proper spark gap between the welding rod and the material being welded. This is achieved by having the flux coating of the rod always extend a proper distance from the metal in the center of the rod, and to melt in a uniform manner as the rod is used. Experiments have shown that the blind person will require considerable practice with this welding rod in order to avoid burns, and to achieve good welding of the two metal parts that are to be joined. A partially sighted operator can use this welding rod without difficulty. Experiments are being continued to find and develop a reasonably priced, practical, portable electric arc welder and spot welder. Some experimentation has been conducted in the use of soldering irons and methods by which a blind craftsman can apply hot solder with a soldering iron to the pieces that are to be joined, but as yet no material results have been realized.

It is probable that the braille stylus project will ultimately recommend a method by which a blind person will be able to make his own individual braille stylus handle. Six different shapes and sizes of braille stylus handles have been formed by using plastic steel, and molding these to fit the individual's hand. One stylus has a point bent at a slight angle. Field experiments are being conducted by some blind persons who reported the problem and requested a solution for it.

SUMMARY

Experience in the effort to develop mechanical devices to solve even a small number of the problems outlined herein illustrates problems that exist in every field of tool development. Managers of workshops for the blind are constantly searching for devices that will enable the average blind employee to increase efficiency in production and quality of work, and it is hoped that this project will be authorized to work with these problems. In the meantime the staff believes that the devices described herein can bring satisfaction to the craftsman in his work and in his hobby activities when they are made available on a production basis.

Because of the limited market for these devices among blind craftsmen as compared with the potential market among sighted craftsman, the staff believes that these devices should be made by a tool manufacturing organization for the sighted, or if made only for blind craftsmen, the cost of patterns, production equipment, and labor should receive special subsidy.

As each of these instruments is perfected and turned to use by a blind worker, the horizon of limitation is broadened for all blind persons.

TRAINING AIDS AND TEACHING TECHNIQUES IN WOODWORKING

JOHN L. THOMPSON
United States Veterans Administration Hospital, Hines, Illinois

It is the primary aim of our Section to prepare veterans to make the personal and social adjustments required of regular community life. Our program provides an opportunity for skill and habit training and for attitude conditioning for performance under permanent conditions of little or no sight. Each patient is scheduled to participate in a program of therapeutic activities which include orientation and mobility, braille, writing skills, shop, counseling, physical reconditioning, and group recreation. Participation in all activities is required except where conditions are so unusual that the activity is medically contraindicated, and there is so little chance of establishing a success pattern that participation for the veteran would be unwise. All units of activity in our Section are considered to be of equal importance.

THE ROLE OF THE PREVOCATIONAL SHOP

In the shop, challenging situations are presented to the veteran in step-by-step fashion. It is planned that each succeeding step be more demanding than the last. As the blinded veteran meets the rigid specifications required in this program, his concept of himself undergoes a positive revision. Participation in the prevocational shop program does much to widen the horizons of men concerning possible performance, pleasure, and responsibilities.

Most tools and instruments which man has devised to make his activity easier and more efficient were developed with the idea that the user would have good eyesight. When a person acquires a severe visual impairment or becomes blind, most tools, instruments, and materials are impossible to handle by normal means, and changed techniques are required. The infinite number and variety of tools, instruments, and materials which any person uses in the normal course of personal, social, and vocational life is such that it is not possible to make all of them in special ways for people who do not see. Principles and special methods have been worked out in our shop program whereby blinded veterans learn to handle ordinary equipment and materials with efficiency and safety.

THE PATIENTS WE WORK WITH

The content of the rehabilitation program which is offered at our Section is influenced a great deal by the type of patient with whom we work.

Since we are required to accept the applications of all blind veterans, it can be seen that there is a tremendous variation of ages to be considered. Our patient group has ranged in age from 19 to 79 years.

Many of our blinded patients have additional disabilities. Loss of hearing, loss of one or both hands, diabetes, loss of the olfactory sense, and poor balance, as is the case in many of the multiple sclerosis patients, are some of the common additional disabilities which require us to modify our regular instructional procedure.

A large number of legally blind patients still retain enough residual vision to enable them to move about a familiar area quite freely. Some of them, with optical aids, can perform certain operations by sight rather than by touch. To work with this type of patient requires that our teaching techniques and procedures be changed considerably.

The group with which we work can probably be considered a typical cross section of the population. The educational background of our patients varies from just a few years of formal education to those with Masters or Doctors degrees. Likewise, their vocational experiences range from the unskilled to the skilled and the professional. In their pre-blind experiences, many of the patients have become quite familiar with many common hand tools and machines. Our shop program, therefore, must be geared to accommodate the varied background of our students.

THE INSTRUCTOR/PATIENT RATIO

The ratio of instructors to patients varies according to the particular shop area. In the basic shop, one therapist can work with three or four patients in a satisfactory manner. In the advanced shop, the ratio will depend on the complexity of the operation which the patient is performing. Orientation to a new machine will require the complete attention of one instructor. Even after the student has learned to operate a so-called "hazardous" machine, he should be under very close supervision. In the advanced shop, then, the instructor will never work with more than two patients at one time.

THE ACTIVITIES IN OUR SHOP

The prevocational shop training at our Section is divided into two parts. In the basic shop, the emphasis is on simple crafts such as leather lacing, weaving a rug, and weaving a reed seat on a footstool frame. The advanced shop projects are in woodworking, metalworking, and wood turning. It should be pointed out that these many shop experiences are presented to the patient in two 50-minute periods each day for an average of 18 weeks. I bring out this fact to emphasize that in a rapidly moving, varied experience program of this type, there is no time for specialization.

THE OBJECTIVES OF PREVOCATIONAL SHOP TRAINING

I would like to list in detail the objectives which we have set up for our shop program. Actually, all of the projects in our program have been planned around these objectives. These objectives also make very good check points for the therapists to follow in the course of their instruction.

A. Independence
  1. Independence of movement in a shop area
  2. Independence of action in performing certain basic manual skills
  3. Independence of action in setting up and operating power machinery
  4. Independence of thought in planning the sequence of operations to conserve time and material
  5. Independence of thought in designing some of his own projects.

B. Orderly work habits
  1. Keeping his working area neat at all times
  2. Proper placement of the tools on his bench
  3. Reporting for class at the proper time
  4. Returning tools to the proper place in the storage cabinet
  5. Development of good safety habits.

C. Increasing finger dexterity

D. Development of bimanual coordination

E. Development of hand-foot coordination

F. Increased use of the remaining senses
  1. Hearing
  2. Tactual
  3. Olfactory.

These objectives are many and varied. We must constantly keep them in mind in order that our sights might not be lowered from our prime target—total rehabilitation of the blinded veteran.

GETTING ACQUAINTED WITH THE AREA

I believe that the planning of a shop area for training purposes is of great importance. It should be large enough to accommodate the planned equipment without overcrowding. Lighting should be adequate to enable low residual vision patients to maintain their maximum performance. Equipment can be so arranged that it will require a patient to move about the entire shop to complete the operations on certain projects.

The woods and metals shop at our Section is a rectangle 30 by 60 feet. The machinery is located along the two long sides. Three tool cabinets are in the area. The lumber rack is located in the room, but other storage is located in a separate area. The woodworking area is located at the far end of the shop with the woodworking tool cabinet close by. In the center of the shop is an island of benches and some sheet metal equipment. This island is invaluable for teaching the blind students to take directions from fixed objects when they are locating a specific machine. It is also very helpful in facilitating movement from one end of the shop to the other in a rapid and safe manner.

The first period that a patient spends in the advanced shop is devoted to a thorough orientation of the area. A clear verbal picture of the shop layout is given. The student is introduced to the other instructors, and he is told the names of the patients who will be working with him in the shop. The sequence of projects is explained to him. We ask the patient to leave his cane in one place in the shop and move out from there by using known landmarks. This will also encourage the utilization of various shop sounds for orientation purposes.

Following the shop orientation, the patient is thoroughly familiarized with the woodworking tool cabinet. He learns the location of the tools which he will be using and is impressed with the importance of returning them to their proper place at the end of each class.

THE WOODWORKING AREA

We have chosen for our first woodworking project a footstool of very simple design. The construction of this stool requires the use of several common hand tools, a few simple power machines and also a few adaptive devices.

By the time a patient starts this project, he should have enough braille to enable him to read a braille ruler. He uses the one-foot ruler and the two-foot ruler to measure the sample stool. Various methods of measuring are explained to the student at this time. All of the adapted measuring devices that are available are shown and explained to him. Also, the use of conventional measuring tools, such as the extension ruler, is demonstrated to the patient. We also show the patient how a simple conversion of standard items, such as a steel tape, will facilitate touch reading.

There are numerous methods employed by the blind to use a handsaw for crosscutting or ripping a board. In our classes, we show the patient several methods that can be used successfully. I believe that any blind person who does much of this type of work after he leaves our Center will decide on his own method for sawing. What we try to do is show him various methods and then let him decide for himself which method he will use. On the wider boards, we employ the use of some special saw guides constructed of wood and aluminum. We find these especially useful for those patients who are not too adept mechanically. The use of a try square to aid in the sawing of a straight line works out very satisfactorily in many instances. Two pieces of wood nailed together at right angles can also be used as an aid in sawing. Sawing narrow boards can be done accurately by merely aligning the saw blade parallel with the edge of the woodworking bench.

The design for the keyhole pattern on the legs of the stool is laid out directly on the wood. To locate the center for the hole in the design, the patient first locates the center of the board and then, by using a try square and a braille ruler in combination, he can measure up the perpendicular the desired distance. Sawing out the design can be done by setting up a pair of saw guides along the scribed lines and then sawing to the middle hole with a handsaw.

The patient is taught how to use a hand plane for smoothing the edges of the boards. A hardware item called a Square E-Z plane guide has proved to be a very useful item for keeping the plane at a right angle with the face of the board.

The angles on the ends of the rails in the stool project are cut on a regular mitre saw. The patient is taught that angles divisible by 7½ degrees can be set up on a conventional mitre box.

The first power machine that our patients operate is the belt sander. We consider this machine to be quite simple to operate, and we feel that if he operates it successfully, he will be ready to move ahead to a slightly more complicated machine. The only modification we have made to this machine is a perpendicular upright which has been fastened to the fence. This gives the operator a two-way right angle for aligning the wood on the sanding belt. The patient is first shown a safe path to the machine from his work-bench. After a thorough orientation of the machine, he is taught the safety sequence which he must follow. This is the first power machine that he operates so we put a strong emphasis on the four-step safety procedure which he will follow on the sander and all subsequent power equipment. The patient uses this machine for sanding the sawed ends of the footstool parts.

The other machine that the patient uses for this first project is the drill press. The drill press is considered to be quite safe to operate, but the fact that adjustments have to be made on the machine before drilling can be done makes it a little more complicated than the sander. We have mounted a compound vise on the table of the drill press. Four horizontal movements of the vise can be made by means of two cranks. Each turn of the crank moves the table one-tenth of an inch. The patient can use the crank for evenly dividing narrow boards and for drilling holes at fractional intervals. The student is also shown the proper method of setting the depth stop. We have found that after only a minimum amount of instruction, most patients can efficiently set up and operate the drill press.

WOOD TURNING

Perhaps the most popular area in our shop program is wood turning. Many of our former patients have purchased wood lathes and are doing wood turning either as a vocation or as a hobby. One reason that the wood turning lathe has such a high avocational appeal is the fact that the entire project can be completed on the one machine. This differs from most woodworking endeavors where several machines are usually required to complete a project.

The patient is first taught a safe path to the lathe. As a safety factor, we ask him to leave his cane under one of the benches in the island in the center of the room. From there, he can square himself on the bench and go forward and make his initial contact with the machine. This is a good time to start impressing the patient with the importance of the safety sequence on the lathe. The patient moves forward to contact the machine with his hands down and out in front of him. He should contact the wooden top of the lathe stand with the back of his hands. We have him use the back of his hands because there is less chance of getting fingers into belts, gears, or pulleys. After the student has made the initial contact with the machine, we ask him to slide his left hand to the end of the machine then turn his hand with the palm up and raise the hand to contact the wheel on the end of the lathe. This contact will determine for the patient the state of rest or motion of the lathe.

The next step in our teaching procedure is to have the patient become thoroughly familiar with the machine. We start with the motor and follow the power through the V-belt to the headstock. From there, we proceed along the bed of the lathe to the tailstock. Nomenclature of the lathe is constantly repeated until the student becomes familiar with the parts. The chisel rack is fastened to the back of the lathe and the patient is shown that by standing in the normal operating position, he can reach forward and select the proper cutting tool.

The motors on the wood lathes in our shop are controlled by a floor-type foot switch. The switch is fastened to the floor and the operator soon becomes familiar with the location. The use of a foot switch allows the patient to have both hands in position before the machine is set in motion. This is especially useful during the early stages of lathe operation when the patient is already somewhat concerned about the revolving wood, the flying chips, and the noise which accompanies the operation.

The lathe is equipped with four-step cone pulleys and, as a part of the initial orientation procedure, the patient is taught how to change the spindle speed on the lathe. Later we expect him to select the proper speed to suit the operation which he is performing.

The material we use for practice turning is a $3\frac{1}{2}$-inch glued-up pine block which is 15 inches long. As a first step, we instruct the patient to smooth the ends of the block on the belt sander. Smoothing the ends will make it much easier to locate the center point. There are several ways to locate the center of the block. A pair of dividers can be used quite satisfactorily. Scribing the diagonals with an awl is another method that is equally as good. We have constructed a device which automatically locates the center point if it is locked across the diagonals. The point can be marked by putting an awl in the device and striking it with the heel of the hand.

Driving the centers into the wood is the next step of the procedure. We instruct the patient to first drive the cup center into one end of the wood far enough to make the circular impression. He then removes the center and puts it in his pocket. The spur center should then be driven into the wood for about one-quarter inch. The spur center should be left sticking in the end of the block. The patient then inserts the spur center into the headstock spindle. He should not release his hold on the right end of the block or it will fall. Instruct the patient to switch his hold on the block from the right hand to the left hand. With his right hand he can remove the cup center from his pocket and insert it in the impression which he had previously made in the end of the block. Then holding both the block and the center in his left hand, he should reach out with the right hand and draw the tailstock to the left until the cup center is firmly seated. Over the years, we have had hundreds of blind patients operate the wood lathes. We have found the method which I have just described as being the best of any we have tried.

We have set up a number of checks which the operator should make before he is ready to start the machine.

1. Is the stock locked in the lathe properly?
2. Has the tool rest been set up and checked for clearance?
3. Is the lathe set at the proper speed?
4. Has the air vent for the dust collecting system been opened?
5. Have the safety glasses been put on and properly adjusted?

All of the wall outlets in the shop are equipped with a lock-type switch. With the beginning operators, we can leave the switch in a locked position until we have checked the setup.

The first step in the actual turning procedure is to turn the square block down to a straight cylinder. To accomplish this, the patient is instructed to select a large gouge. The accepted way for a sighted lathe operator to hold the chisel is by putting his hand on top of the blade. The only variation we make in this is for the operator to hold the blade of the chisel from the underside. This will allow him to guide the knuckle of his index finger in the hollow of the tool rest and thus have better control of the depth of the cut. During the early stages of the cutting procedure, we have the patient stop the machine quite frequently. This will allow him an opportunity to relax a bit and also will give the instructor a chance to emphasize the safety procedure. We have established a set sequence for the patient to follow when he stops the lathe. First he will draw both hands back from the lathe and let them fall to his side. Secondly, the patient should shut off the switch. Finally, using the previously mentioned safe path, he should check the handwheel to make sure the motion has stopped.

After the cylinder is cut, the patient is instructed to use rough and then smooth sandpaper on the wood. The work is sanded at this time so that the scribe marks, which are made in laying out the design, can be readily located. Working from a selected sample or from a plan of his own, the patient can lay out the major elements of his design with a pair of dividers.

Our lathes are equipped with a standard set of eight cutting chisels. During the course of the practice turning the patient learns to use these chisels for making certain basic cuts. We have found that in many instances, it is very helpful to assist the beginner by placing our hands over his to aid him in guiding the chisel. As soon as he gets the "feel" of the chisel, he can proceed on his own.

The next step in lathe work is faceplate turning. Instruction is given on how to fasten the plate to the wood, mounting the block on the lathe, selecting the proper chisel, and manipulating the tool rest for the best cutting results. In the regular sequence of projects, the patient will complete a base for his lamp and turn out a two-piece bowl. Using the lathe as a horizontal drill press, the patient can drill a one-inch hole in the base to accommodate the shank of the lamp column. For this drilling operation, the drill is held in a geared chuck which is inserted into the tailstock quill.

The entire finishing procedure can be completed on the lathe. This includes sanding, filling, staining, French polishing, and waxing. Most of our patients can complete this entire operation without any difficulty.

The final step in the lamp project is wiring the lamp and attaching the hardware. We had previously drilled a ⅜-inch hole through the column and then plugged the ends of the holes. The patient must drill out the plugs and then drive a piece of ⅛-inch pipe into the top of the lamp. The hardware is then fastened to the exposed threaded end of the pipe.

The patients who plan to continue wood turning after they return home must be taught a method of drilling the ⅜-inch hole through the center of the column. The first step in this procedure is to locate the centers in the manner mentioned previously. A geared chuck is screwed on the spindle nose and a ¼-inch drill is inserted into it. Center one end of the block on a 60 degree center in the tailstock. Center the other end of the block on the ¼-inch drill. Then, by turning on the power and pulling forward on the tailstock, a guide hole can be drilled in the block. After the guide hole is drilled in each end, the same process can be repeated using a ⅜-inch twist drill. A ⅜-inch electrician's bit is put into the hollow chuck so that it extends out slightly more than half of the length of the block. The hole can then be completed by drilling halfway from each end. The ends of the holes are then plugged to enable the operator to center the work on the lathe.

THE BAND SAW

The use of the band saw in our shop has been limited, to a large extent, to controlled type sawing. The patient is taught how to set up the fence properly for ripping. He is also taught how to use the mitre guide for crosscutting purposes. We have developed a jig for use on the saw which enables the patient to cut circular discs that are any fractional diameter between 2 and 7½ inches. One of the optional projects that we have in the shop is a combination wood and plastic lamp. To rough cut the numerous discs for this lamp requires the operator to set the jig for four different diameters.

THE JOINTER

Over the years, a number of our patients have learned how to set up and operate the wood jointer. Instruction on the machine starts with a thorough familiarization which centers primarily around nomenclature and safety. The patient should learn how to change the depth of cut and also how to adjust the fence for such operations as beveling or rabbeting. A hold-down type pusher should be used when surfacing small pieces on the jointer. When jointing wider boards, the patient can put his right hand on top of the board. His left hand should be used to hold the face of the board against the fence. To make sure that the fingers of the left hand will be in a safe position, the operator should lower his fingers until they touch the table and then raise them up the board about two inches. He should be cautioned not to move his hand from this position until the cut has been completed. It is very essential that the floor area around the jointer be kept free from all debris to avoid tripping the operator.

THE RADIAL ARM SAW

Operation of the radial arm saw has been limited to a few carefully chosen patients. In our program, time is one of the determining factors as to how far a patient will progress. In selecting those who should be given instructions on this saw, the therapist must consider such things as interest, aptitude, previous experience, and the work and safety habits which the student has demonstrated in the early part of his training. We must remember that even though a blind person can learn to operate this machine successfully, one careless mistake can have disastrous results. We have equipped our saw with an electronic brake. This brake stops the machine in four or five seconds. Without the brake, this type of saw will free coast very silently for several minutes.

The patient is shown the correct method of crosscutting on the saw. We instruct him to position his left or holding hand and then turn on the saw with his right hand and take a predetermined safe path to the handle of the saw. Various methods for measuring the length of the cutoff have been devised. The length of cut can be measured with a ruler and marked by making a small nick in the edge of the board. Another method would be to measure from the end of the board to the saw blade and then, without moving the board, make the cut. Duplicate cuts can be made by clamping a block to the table top.

Switching the saw to a ripping position can be accomplished after only a minimum amount of instruction. Setting the ripping width can also be done quite easily. A brailled scale is available for the DeWalt saw. Using this scale, the patient can readily set the desired width of cut. Setting the width on a saw which is not equipped with the special scale is not too difficult. The floating guard rings can be raised to expose the blade and held in that position with a block of wood. It is a simple matter then for the patient to set the width of cut by measuring from the inside of the fence to the inside of the blade.

A very simple type of pusher can be constructed from scrap material. Two blocks of wood can be nailed near one end of a piece of wood which is about 15 inches long and 4 inches wide. One of the blocks is used as a grip. The other block is ahead of the knuckles and will strike the saw guard and stop the pusher. The pusher is used in the ripping operation and can be used over and over again before it must be replaced.

MULTIPLE DISABILITIES

I would like to deviate now from the regular woodworking practices and tell you something about the work we have done with those blind patients who have additional disabilities. As I mentioned earlier, these additional disabilities are varied and numerous. However, I will confine this discussion to single and double arm amputees.

I am sure that you can imagine the difficulties that a blind amputee would encounter in trying to take care of his daily living needs. Brushing his teeth, taking a bath, combing his hair, dressing himself, lighting a cigarette, dialing a telephone, or opening a door are just a few of the things that he will need to do each day of his life. We in the shop are directly concerned with helping these patients solve some of their everyday problems. In the first place we make many assistive devices for the amputees which enable them to more independently take care of their daily needs. We also scheduled these patients for regular shop participation. Although they are not able to perform adequately in all of the mechanical areas, there are certain activities which will give them good training in the use of the prosthesis. I think that one of the most rewarding facets of our work is observing the day-by-day progress which these blind amputees make. Also, it is very satisfying to have the patient discard some of the assistive devices and be able to perform the activity by himself. I am sure that you realize that working with the multiple handicapped requires a great deal of time, an infinite amount of patience, and almost the exclusive supervision of the instructor.

The double arm amputees can operate the weaving loom quite satisfactorily. Those who are fitted with a prosthesis can grasp the shuttle with the hook and put it into the shed. Considerable difficulty may be encountered in getting the hook caught in the warp, but through practice and perhaps the help of the other stump, the procedure can be accomplished. Those amputees who have the Krukenberg hand on one arm can grasp the shuttle with the "fingers" and then proceed to put it in the shed. The Krukenberg can also be used to pull the shuttle on through the shed. Getting the shuttle all the way through the warp requires a great deal of physical maneuvering on the part of the patient, and he has to practically stand on his head to accomplish his purpose. Finally, the amputee can grasp the beater handle with his hook and pull it forward.

Several double arm amputees have performed quite well on the wood turning lathe. Certain parts of the sequence required assistance but we have had patients who could independently perform about 80 percent of the operations. By the time a patient has completed his practice turning, he should be able to select the proper cutting chisel for the job he has to do. Grasping the handle of the chisel with his hook and holding the blade with his Krukenberg, he is able to turn a square block down to a cylinder. Usually, the operator will check the progress of his work by using his lips. This seems to be quite crude, but it is the best way that he has of getting a picture of his progress. At times, the operator becomes quite tired because of the angle he must hold his prosthesis. To relieve this situation, we found it quite convenient to allow the operator to sit on a stool in front of the lathe. Sanding the completed lathe project is really a simple matter for this type of patient. Holding the edge of the sandpaper with the hook and supporting the underside with the Krunkenberg, he can do a very effective sanding job. We find that he can do some of the operations as well as the other blind patients. Drilling the one-inch hole in the base of the lamp is an example of how well he can perform. Applying the French polish presents quite a problem for these patients but the waxing process can be done satisfactorily without any special difficulty. We encourage the blind amputees to perform every task that they possibly can. At the end of each period, most of them are capable of cleaning their own benches and machines.

Blind single arm amputees are not quite so limited in their performance. Most of them can complete all of the projects in the basic shop and part of the projects in the advanced shop with only minor modification of techniques. One of the patients became quite adept at tying the fringe knots on his rug. He would smooth out a number of the strings and place them in his hook. Then, using his hand, he would count out the required number of strands and let the others fall. After making the knot with his hand, he would again hold the strands in his hook while he worked the knot tight with his hand. In woodworking, this same patient did his measuring by laying the braille ruler on the board, and holding it in place with his hook. Then, using his finger and an awl, he could make the required measurement. To operate the belt sander, the single arm amputee can hold the board in place with his hand and turn on the switch with his hook. I have detailed only a few of the performance capabilities of the blind amputees. Training in this area is limited only by the industry and desire of the patient and the ingenuity of the instructor.

CONCLUSION

The numerous detailed processes which I have given here today may have impressed you as being very elementary. However, it is my belief that this step-by-step, ever more demanding approach, is the best method for instructing the blind in shop activities. To the sighted, some of these accomplishments may appear to be very insignificant, but to the blind person, each one is a major accomplishment. As the successes continue, the patient gradually gains in confidence and independence and thus is well along the road to total rehabilitation.

THE USE OF TECHNIQUES TO REPLACE SPECIAL PURPOSE TOOLS IN METALWORKING

ISAAC L. MYERS
State Department of Public Assistance, Seattle, Washington

For the past ten years, the Washington State Department of Public Assistance, Services for the Blind, has operated a workshop employing blind men in the fabrication and assembly of light metal parts. We have worked on a variety of products ranging from parts for guided missiles to stands for outboard motors; from special splines used in the control of atomic reactors to taillights for trucks; from aircraft parts to portable toilets; from the refueling boom on a jet tanker to a sprinkler for potted plants. We have done work for over 50 companies ranging in size from large aircraft companies to the one-man machine shop across the alley. We have worked with aluminum, nylon, magnesium, stainless steel, and phenolic compound products. We have paid out over a million dollars to blind workers and bought over $75,000 worth of metal fabricating machinery, from fingernail files to hydraulically controlled milling machines. All this we have done without the expenditure of public funds or private endowments.

On the first of May of last year we turned over this operation to a non-profit corporation as a free-standing enterprise.

I do not consider myself an expert in the employment of the blind. I do feel, however, that I was well qualified to set up and operate a machine shop, as 35 years ago I took a five-hour lab course in machine shop while attending college. Possibly our very naïvete, together with a lot of luck, worked to our advantage.

We have found that the most important criterion in operating a machine shop for the blind is to "keep it simple." Many of you have heard the following story, but I think it illustrates a point which we bureaucrats are all too likely to forget. A New York plumber of foreign extraction with a limited command of English, wrote a government agency and said he found that hydrochloric acid quickly opened drainage pipes when they got clogged, and asked if it was a good thing to use. An agency scientist replied, "The efficacy of hydrochloric acid is indisputable; but the corrosive residue is incompatible with metallic permanence." The plumber wrote back thanking the bureau for telling him the method was all right.

The scientist was a little disturbed, and showed the correspondence to his boss—another scientist. The latter wrote the plumber, "We cannot assume responsibility for the production of toxic and noxious residue with hydrochloric acid, and suggest that you use an alternative procedure." The plumber wrote back that he agreed with the bureau—hydrochloric acid works fine. A top scientist broke this impasse by tearing himself loose from technical terminology and writing, "Don't use hydrochloric acid. It eats hell out of the pipes."

We have found that some of the simplest devices have worked better than some complicated, expensive fixtures. We have held tolerances to .010 inch by driving two shingle nails in a piece of plywood.

There are several basic principles we have learned from our experience:

1. Don't try to revolutionize industry to fit the blind.
2. By and large, a machine or fixture that will do a job for the sighted will work equally well, unmodified, for the blind.
3. Don't expect a blind worker to work competitively with a sighted person on a job where sight is a determining factor in quality or quantity of work.
4. Be selective in placing a man on the operation he likes and can do well.
5. We need to reassess our judgment as to how well a blind worker utilizes his other senses.

In order to survive the economic battle in which we are all engaged the blind worker must, whenever possible, employ the tools of his sighted competitors. We do not wish to minimize the many fine aids which have been developed over the years for the exclusive use of the blind. We must continue to use these aids and explore all possibilities for new and improved devices. What I wish to emphasize, however, is the prudent and pratical use of these devices. We live in a sighted economy and a blind person must, as nearly as possible, function as a sighted person.

The coming of the industrial revolution and the practice of interchangeability of parts has worked out advantageously for the blind worker. No longer can a worker fabricate metal parts with a hammer and anvil. Tolerances have become to close to depend on sight for accuracy. In order to make a part that will fit on any of a thousand different machines, mechanical jigs and fixtures must be used. The same drill jig that is used by a sighted worker can be used by a blind worker. The same cutoff stop on a shear or saw is used by both. The same template is used by all.

We have several machines in our shop which could have been very well designed for the exclusive use of the blind. One is a standard vertical milling machine with a hydraulic tracing attachment. A template of a part to be fabricated is bolted to one end of the milling machine table under a stylus. The material to be machined is clamped to the table under the cutting head some 12 to 18 inches away. The operator moves the stylus around the template, and the part is milled in three dimensions to an exact replica of the pattern. This machine has not been modified in any way for our use.

Another machine is the spindle shaper. This has a fixed cutter protruding from the center of a four-foot square table. The blanks are clamped to a pattern. The two are then held against the cutting tool with the pattern riding against a collar on the tool. All drilling is done through drill jigs. Bending and shearing are done against fixed stops. Material is sawed against fixed fences. No element of size or thickness is left to the judgment of the machine operator.

These machines are operated by totally blind men. They have not been changed in any way. Neither have we changed the standard drill jigs used for the manufacture of parts by sighted workers. No special safety devices have been employed on our milling machines, metal cutting saws, punch presses, lathes, or other power machinery. No guide wires are stretched throughout our shop to guide the workers from machine to machine. Yet, in ten years of operation, we have had not one serious accident—not even a lost finger. We want these people to be able to work in any shop where they are qualified operators without making it necessary for an employer to change his shop to fit the man.

Since our shop is operated specifically for the benefit of the blind worker, we have tried, whenever practical, to use blind men in the actual operation of all machines. We have found, however, that to meet the demands of our customers for precision and quantity of work, we need qualified machinists for setup work. Nothing is so expensive as cheap labor when it may involve the rejection of parts which have cost much in time and material.

This brings us to our third principle listed earlier—don't work a blind man under a handicap. There are many jobs which a blind man may be able to do, but in which sight is so important a factor in quality and quantity of work that it is impractical for him to do it. It is quite possible that, with the proper electronic devices, a blind man could drive a car down the highway, but with our present technology I wouldn't advise it. It is not only economically unsound but is an injustice to the blind worker to ask him to compete against a sighted worker in a situation where the lack of sight makes the odds too great against him.

We have one job in our shop on which we use sighted help. This is on a riveting machine where the contour of the assembly makes it impractical for a blind man to rivet the parts together. True, we could build a jig for each different assembly, but the time required to build this jig would be ten times the amount of time used in squeezing the rivet. Even with proper jigging it would be difficult for a blind person to do an acceptable job.

It is my opinion that some workshops for the blind have missed out on many lucrative subcontracts because they have insisted that all labor be performed by blind employees. I believe that in the past this has kept the blind in occupations which demand low pay and excluded them from the better paying jobs, such as machinist and sheet metal worker. For example, on the riveting job mentioned above, the riveting of the assembly was only a small part of the total job. The parts were all fitted into a drill jig, the holes were drilled, the parts were removed, the holes were deburred on each side and then reassembled with sheet metal fasteners by blind workers, ready for the riveter who, incidentally, was a paraplegic.

It may be possible that we have employed too great a proportion of sighted to blind help in our shop. Last month we had on our payroll 49 blind and 23 sighted employees. Of the sighted men, there is an assistant foreman (the other foreman was blind), one truck driver, two inspectors, two stock clerks, one janitor, three riveters (who also worked on other production jobs where sight was required), and 13 machinists who did setup work and toolmaking. Of the 23 sighted employees, 19 were vocational rehabilitation clients of the general agency of vocation rehabilitation. (This condition does lend some support to the possibility of workshops for the multiple handicapped.)

I think that too often we who work with the blind, and the blind themselves, feel they have to prove to the world they can do anything that any sighted person can do. In this age of specialization, we must try to do well the things for which we are physically and mentally endowed. We can't all be astronauts like Shepard or Glenn.

The fourth principle is well recognized in all personnel practices, but has often been neglected in the employment of the blind. That is the assignment of work on the basis of the worker doing well that which he likes to do. For too long we have attempted to give blind people jobs of a menial or repetitive nature. We have failed to exploit their capabilities. We have failed to use the remedial sight of the partially sighted to the fullest extent. We have failed to realize how much hearing and touch contribute to the operation of machines. In a shop where men vary in degree of sight from total blindness to the minimum requirement for legal blindness, it is important to make use of every bit of usable vision. For example, we have many countersinking jobs where a minimum of sight makes it possible for a drill operator to find the hole to be countersunk if the light is focused properly. Other skills, however, are often more important than those requiring a small amount of vision. It is interesting to note that we have eight employees in our shop whom, because of their versatility, speed and quality of work, we have rated as premium workers. Six of these men are totally blind—corroborating our opinion that if a worker is properly trained and placed, sight need not be an important factor in machine operation.

Finally, we need to explore further the vocational possibilities of the other senses. In the short time I have been engaged in work for the blind, I have seen men who thought they would spend a lifetime in basketweaving and chaircaning become skilled machine operators, earning as much per hour as they made in a day.

Another good example is the new concept of mobility. We have people come into our center wholly dependent on friends to get from place to place, and go out in six weeks time able to go anywhere in the city, with the use of their canes alone. Mobility training today requires formal training and at least two schools offer graduate training to mobility therapists.

We need to train other technicians in other fields so that, when we ask an employer to hire a blind man, we offer him a whole man capable of demanding and earning a wage, not based on his amount of vision, but upon his contribution to the employer's organization.

I am optimistic about the future possibilities for skilled workers in the field of metal and plastic fabrication. Automation, I believe, will have its greatest effect on the unskilled, inefficient worker. As long as we are developing new machines, there will always be a place for the custom shop. There will always be prototypes that must be, to a large extent, handmade. The consumer will always want something that is not just like a million others. Here is the field we need to look to for continued, lucrative employment.

TRAINING AIDS AND TEACHING TECHNIQUES IN METALWORKING

RICHARD R. FRIEND
State Commission for the Blind, Newark, New Jersey

It is our basic premise that a technique is preferable to a special tool or device, for a technique is transferable from one set of circumstances to another, whereas a special device may not be. There are, of course some standard tools which have been adapted for tactual reading in our shop.

In discussing the various machines and how we approach them, the basic pattern of safe and danger areas is always pointed out to the student. He is taught the location of the on/off switch in relation to every part of the machine, and he is cautioned about certain safety regulations such as removal of neckties and rings and the wearing of proper apparel while working at the machine.

After discussing safety thoroughly, we introduce him to each of the machines in the shop and explain something about its use. We endeavor to help him develop skills which are transferable from one machine to another. We introduce him to measuring devices, such as the Clic-O-Matic rule, the adapted micrometer, and the use of standard pieces of stock for measuring. We also include shop mathematics, i.e., the decimal system and decimal equivalents; series, such as the three sets of drills (numbers, fractions, and letters) and the reasons for the three scales; the various thread series; some information about taps and dies; and taper series used on lathes and milling machines (Morse taper for lathes, Brown & Sharpe taper for milling machines, etc.). This information is not merely presented; rather, it is taught as the need for its use arises in terms of a project on which he may be working. We find that to teach the use of taps and dies and the various thread series in a classroom situation has much less meaning than to teach this material when the client uses it on a project or operation. Other skills, such as the use of the micrometer, are picked up as soon as the trainee is required to turn material to given dimensions. By the time a student is ready for our machine shop, he has been taught to identify and use the basic hand tools, e.g., pliers, screwdrivers, hammers, files, wrenches, and others.

The first machine that he will use is the shaper on which he will cover planing and working to a shoulder. He will then move on to a lathe where he will cover the following operations: facing, turning, turning to a shoulder, boring, drilling, turning between centers, tapering with use of a sine bar, turning between two shoulders, angle turning and chamfering, deep boring, matching two fitted parts for slip fitting, threading using taps and dies, machine threading using a 60-degree tool, eccentric turning, and special types of work such as faceplate mounting and knurling.

We attempt to cover some of the major uses of the milling machine, such as shouldering, slitting, straddle milling, and the differences between horizontal and vertical milling.

The drill press is utilized for secondary operations in conjunction with lathe and milling machine assignments. The student is taught to cut stock with a power hack saw and with a metal-cutting band saw. A few of our people are introduced to grinding of tools, both freehand and with simple jigs. As the person progresses, we help him with some limited layout work and planning of individual projects. Often a client brings in projects which he would like to do for himself. If this type of work stimulates his interest and helps broaden his imagination, we feel it is worth the extra time and effort.

We give planning and layout work to those students who learn to set up and understand basic machining procedures. In instructing a student in layout, we teach him to use standard size materials for scribing lines at given distances from the edge of a plate. For example, if we desire to place three holes an inch apart down the middle of a 2-inch by 5-inch piece of plate stock, we will lay the 2-inch plate on edge, place a 1-inch parallel alongside of it, and scribe a line down the length of the piece. Turning the plate on end, we lay the parallel alongside and scribe a crossline. Reversing the plate to the opposite end, we scribe a second line. This gives the intersections for two holes. By placing the parallel on top of the plate, with its edge alongside of the crosslines, we can scribe a crossline on the opposite side of the parallel. We will now have three crosslines one inch apart marked off on our plate. By using a small center punch we can feel the intersections and center punch the three spots for drilling.

This same project can be carried out with the use of the Bridgeport miller. We place the 2-inch by 5-inch piece of plate stock in the vise of the milling machine, and move the table feed until the center drill is directly over the upper left-hand corner of the plate. Since the Bridgeport miller has a lead-screw pitch of 5 turns to the inch, we can move the work through 2½ turns with the table feed, thus positioning the center drill over the center line of the plate. Using the right-angle feed, we can turn the work away from us 2½ turns and drill the first hole. After lifting the drill, we can advance the table 2½ turns further and drill the second hole. We repeat this operation for the third time and drill the third hole. By letting the machine measure for us, we have been able to drill the three prescribed holes accurately. Obviously, this machine makes certain types of layout work substantially easier than using scribes and other measuring devices. Either method, however, is acceptable and practical.

New Jersey is an industrial state; therefore a knowledge of machines can be of use to our clients in terms of future vocational goals. Our center has two major functions: first, to evaluate the student's potential; second, to train him prevocationally. The question arises as to what method can be used to evaluate a student's abilities. Obviously, we cannot determine his learning speed or comprehension unless we attempt to teach him something. In our opinion it would be wasteful and ineffective to manufacture artificial tests. Therefore we have developed our machine shop so that all the acquired knowledge and skills, which would be by-products of an evaluation period, will be later utilized in terms of a vocation or avocation.

THE SHAPER

Upon approaching any machine, we emphasize the safe and danger areas, and insist that the client locate the line switch. Of course, during the initial instruction period the machine is disconnected. While the machine is at rest, we allow him to examine it thoroughly. We then begin to discuss the machine and its parts, noting its nomenclature as we progress. We start at the source of power, and from the motor and its pulley we follow the power train to the countershaft, stopping here to explain its use. Then we proceed from the countershaft to the main drive pulley, and so on, through the integral parts of the machine, until we reach the cutting tool. These steps are repeated until the student has attained familiarity with the machine.

The shaper is a reciprocating machine, and we show how the rotary motion of the motor and countershaft is converted to reciprocating motion by means of an eccentric and rocker arm. We lengthen and shorten the stroke and make other adjustments which will help the student understand the machine. We then place a piece of work into the vise on parallels, with the axis of the cylinder facing front to back, and show the student how it should be set up. We usually remove the piece of work and have him put it back in the same position. We then show him the different feeds—first the downfeed and second the cross-feed. We explain that if the tool reciprocates front to back, the work must be moved from side to side in order for the tool to peel metal from it. The machine is then turned over by hand, letting the student look at the relationship between the tool and the piece of material being machined.

When we find that he understands the procedure, we will start to operate the machine. Putting the left hand on the ram and the right hand on the cross-feed crank, the student is able to determine when the work should be advanced with the cross-feed. The tool on the shaper cuts on the forward stroke and the machine must therefore be fed when the tool travels away from the operator (or on the backward stroke). When the student has learned the rhythm and can coordinate his hands so that the work has a smooth surface, he is ready to start his initial assignment.

His first assignment is to plane an aluminum cylinder $1\frac{1}{2}$ inches in diameter and approximately 2 inches long into a square $1\frac{1}{16}$ inches on a side by 2 inches long. He is instructed that all feeds on his machines are calibrated in .100 inch per turn. Since the cylinder is $1\frac{1}{2}$ inches in diameter and the square is $1\frac{1}{16}$ inches on the side, we must therefore remove $\frac{7}{32}$ inch from either side or approximately .218 inch. We cannot remove .218 inch in one cut, so successive cuts will need to be taken.

The next step is to position the work with the cross-feed so that the tool is as nearly over the center of the work as is possible to determine by touch. Utilizing the downfeed, we advance the tool until the point just contacts the cylinder and makes a light scratch on it. We can then assume that this is the top point and the point of reference from which we must work. Now the work is moved to the left and the downfeed advanced one-quarter of a turn, or .025 inch, clockwise. The work is then fed crosswise while the machine is running and the tool peels off the metal, planing .025 inch completely across the work. At this point we stop the machine. The work is again moved to the left by turning the cross-feed crank clockwise, the downfeed advanced .025 inch (or a one-quarter turn), the machine turned on, and the process repeated. We will take eight cuts of .025 inch each, thus planing off .200 inch. Since the total cut desired is .218 inch, we must then advance the feed an additional .018 inch. If one-quarter of a turn of the feed is equivalent to .025 inch, clearly something less than a one-quarter turn will equal .018 inch. We use the clock method of reference in working with any of the tools. For example, if the crank is straight up and down, we would call this 12 o'clock. One-quarter of a turn clockwise would then be 3 o'clock. If we were to consider this scheme for a moment, we will infer that each 5 minutes on the clock face is equivalent to a little more than .0083 inch. Accordingly, in approaching the .018-inch cut, we can see that 10 minutes, or about a one-sixth turn, will give .016 inch, and for most practical purposes, .002 inch is well within the assigned tolerance range.

By way of review: if the cutter had initially contacted the work at 9 o'clock, we would take eight cuts (the handle being at 9 o'clock), and then take the finished cut, advancing the crank to approximately 11 o'clock. This completes the first side of the piece. We now turn the piece over, put the flat side down on the parallels, and tighten it again in the vise. Since the piece is the same thickness whether the flat side is down or up, the starting point of the second face will be exactly where the tool was left at the completion of the first side. Our procedure for the second side will be to advance the tool .025 inch for eight successive cuts, taking a finished cut of .016 inch (or 10 minutes on the clock), to complete the second side. We now have two parallel flat surfaces of the four necessary to make a square.

Our next problem is to develop some technique or method of assuring that the next cut will be at right angles to the two existing parallel flat faces. The piece could be positioned in the vise using a machinist's square, but we believe that we have found a simpler method. Since the jaws of a vise are vertical and the tool on the shaper travels on a horizontal plane, if we were to turn the work crosswise, clamping the two flat faces between the jaws of the vise, we can then take a cut down the length of the piece and this flat must be at right angles to the two existing faces. The next step would be to remove the piece from the vise, turn it lengthwise back to front, place the 90-degree cord firmly on the parallels, and repeat the planing process until there are no curved surfaces between the junction of the two vertical flats and the horizontal one on which we are now working. We then turn the piece over and complete the side that has a partial flat on it, again planing the work until the corners are square. At this point, to assure a good square piece, we will make no adjustments on the machine, but loosen the vise, rotate the work through 90 degrees, and take another cut across the top of the work. The block should then be squared.

During the process of making a square, we have attempted to accomplish the following:

1. Develop coordination between the left and right hand
2. Develop some understanding of coordinate motion
3. Show a method of measuring with a machine
4. Show how to establish a right angle with a machine accurately
5. Allow observation of the tool peeling metal from the work.

Any or all of these acquired skills may be transferred to other machines and projects as the student progresses.

Working to a shoulder with a shaper requires one additional skill: the ability to take a given point and work to it. For example, if we wish to cut a .500-inch step out of a piece of material, we would take a cross-feed cut of five turns, move the work to the left, advance the down feed and proceed with the second cut. Successive cuts are taken until the shoulder has reached the required depth.

Utilizing the above-mentioned techniques, the student is required to make three finished squares without assistance, which he will mount later in his vise at 45 degrees to the horizontal and shoulder out a V-block. Some intermediate steps in terms of instruction and other projects are introduced should the student have difficulty with the basic assignment.

THE LATHE

When the student has learned to operate the shaper, and has learned the skills mentioned, he is ready for instruction on the lathe. In order to eliminate confusion about the position of controls and other parts of the lathe, we will refer to a South Bend ten-inch lathe in this discussion.

We have found that a blind person learns much more quickly using concrete materials than from mere description; consequently, we give all basic instruction while standing in front of a machine. We follow the same safety procedures with the lathe as with the shaper, i.e., disconnect the machine so that it cannot be turned on accidently, et seq.

When a student stands in front of the lathe, he finds the headstock on his left and the tailstock on his right, separated by a long casting known as the bed. Mounted on the bed in such a manner that it may move from side to side is the carriage. From the top of the carriage its principal parts are: the compound with the compound feed, the cross slide, and the cross-feed. Immediately to the right of the cross slide is a nut used to lock the carriage in a fixed position on the bed. The lower section of the carriage is known as the apron, on which is found a large wheel and crank. This is called the longitudinal feed. This control moves the carriage from right to left or toward and away from the headstock.

After the student has experimented with these controls to become familiar with them and what they do, we proceed to examine the more complex part of a lathe, the headstock.

The principal part of the headstock is a hollow spindle, threaded externally to hold a chuck and fitted internally with a Morse taper to accommodate a center. Mounted axially on the spindle is a cone pulley through which the lathe receives power via a belt. This belt is driven by the countershaft, which is driven by another belt from the motor. The cone pulley has three steps, as does its counterpart, the countershaft cone pulley. The countershaft, in turn, has two speeds, obtained by shifting the motor belt.

The back gearing and the back gearing lever are shown, and it is explained that their function is to reduce the speed of the lathe and increase its torque for heavy roughing cuts. Mounted on the left-hand end of the spindle is a gear known as the spindle gear. This drives the quick-change gear box through a series of gears known as the gear train. The quick-change gear box is mounted on the lower left-hand end of the bed directly in front of and below the headstock. The quick-change gear box will be discussed in greater detail below.

Immediately below the spindle gear on the left-hand side of the headstock is a pair of gears called the tumbler gears. These are set in such a fashion that they may be tipped up and down, and either one or two gears may be brought into play in relation to the gear train. As we can see, if an even number of gears meshed or engaged, we will reverse the direction of rotation between the two gears at the extremities of the gear train. If an odd number of gears are meshed, the direction of rotation of the end gears is the same. Thus, we may reverse the direction of rotation to the quick-change gear box at the lower left-hand end of the lathe by either tipping the tumbler gears up or down, to bring into play an odd or even number of gears between the spindle gear and the quick-change gear box. The quick-change gear box has two levers on the front by means of which the lead screw may be adjusted for heavy or light cuts. The lead screw is the source of power to the carriage.

On the front of the carriage are several controls. The first, starting at the left, is the longitudinal feed lever mentioned before. Immediately to the right of this is a star-shaped knob or wheel, the friction knob, for stopping or starting power feeds. Just to the right of this knob is a lever control which allows us to transmit power to either the longitudinal feed or the cross-feed as desired. The little lever on the extreme right-hand side of the apron or lower portion of the carriage is the half-nut lever which will be discussed for instruction in cutting threads.

We now proceed to the tailstock and study its parts. The tailstock has a hollow spindle which does not rotate but may be moved toward the headstock or advanced by means of a control wheel on the right-hand end. The whole tailstock may be moved up and down the bed by releasing its lock with a wrench, and sliding it with the hand to any desired position. The tailstock spindle has a lock which may be brought into play when the operator wants the tailstock held in a given position for various operations. The center of the tailstock spindle is fitted with a tapered hole in which different tools may be held—centers, drill chuck, etc.

Returning to the carriage, we find that the compound is fitted with a T-slot to accommodate various types of tool holders. The one most frequently used is known as a conventional tool post. This is a cylindrical, forged piece of steel with a flange at the bottom. The flange fits into a rectangular block which slides in the T-slot of the compound. There is a vertical slot milled through the post to accommodate a tool holder. A round, hollowed-out washer fits over the tool post and rests firmly on top of the compound. A rocker (a curved piece of steel) fits into the hollow washer through the slot in the tool post to permit a means of adjusting the height of the tool point. A setscrew turns down vertically through the top of the post and locks the tool holder, rocker, and washer firmly in place by pulling the bottom of the tool post tightly up into the T-slot.

The various parts of the lathe are reviewed over and over, until the student becomes thoroughly familiar with them. If the student has a mechanical bent, and seems to comprehend the lathe and its principal parts, we will show him additional attachments such as collets, faceplates, dogs, and centers which he will use to hold materials for various operations.

USES OF THE LATHE

Facing

We will now attempt to discuss the uses of the lathe and start some practice operations. We usually start instruction and practice on the lathe with a facing operation, and the student is shown the need for centering the tool at the proper height. He is usually given the center which is put in place. He must then raise and lower his tool by using the rocker and tool post, until he is able to set his tool at the proper height or center. This procedure is repeated until he has acquired facility in this technique since this is a necessary part of the setup for further operations.

We are now ready for facing, center drilling, and drilling. The student is given 20 or more aluminum discs which have been cut from $1\frac{1}{2}$-inch round bar stock to a thickness of approximately $\frac{3}{4}$ inch. He is shown how to put one in the universal chuck and prepares to drill it. He places the center drill in the drill chuck of the tailstock and moves the tailstock from the end of the lathe toward the work until it touches the surface. He then locks the tailstock to the bed, starts the machine, and rotates the tailstock handwheel, feeding the drill into the work. He will stop after he has advanced the center drill approximately $2\frac{1}{2}$ turns or $\frac{1}{4}$ inch into the work, and turns off the machine. He then rotates the handwheel $2\frac{1}{2}$ turns counterclockwise to return it to its original position. He will unlock the tailstock, slide it to the right, remove the center drill, and replace it with a $\frac{1}{4}$-inch twist drill. He again slides the tailstock up so that it is almost in contact with his work, and uses the $\frac{1}{4}$-inch twist drill to make a hole completely through the piece which is rotating in the chuck. After returning the drill to its original position by rotating the handwheel counterclockwise, the tailstock is pushed away from the headstock and locked in position at the end of the bed. This removes the danger of dropping the tailstock by pushing it off the end of the lathe. He removes the $\frac{1}{4}$-inch twist drill from the chuck in order to prevent scratching the back of his hand on it while proceeding with other operations. Using the longitudinal feed and the cross-feed, the tool is then brought up until it contacts the surface of the piece which is held in the chuck. He then turns the cross-feed counterclockwise until the tool is clear of the edge of the disc. Using the longitudinal feed again, the carriage is moved slightly to the left, which will place the tool in a cutting position. The machine is turned on and the tool is fed with the cross-feed clockwise until it has reached the center of the work, removing metal as it travels.

We are able to determine the center of the material as follows: Our material is $1\frac{1}{2}$ inches in diameter; therefore, the center is $\frac{3}{4}$ inch (.750 inch) or $7\frac{1}{2}$ turns (.100 inch per turn) of the cross-feed crank after the tool initially begins to cut the material. The tool is drawn back by turning the cross-feed lever counterclockwise $7\frac{1}{2}$ to 8 turns thus bringing the tool beyond the edge of the material. The carriage is unlocked and with the longitudinal feed, the tool is moved slightly to the left, readying the machine for its second cut. This same procedure is repeated until a sufficient number of cuts have been taken to remove all rough surfaces from the disc. This operation is known as facing.

We finish all of the 20 discs on one side by repeating the steps above. The second side of the discs are done in the same way with one exception, namely, we wish to face off the piece to a given thickness. We again place the piece of material in the three-jaw chuck with the finished side to the left. Since the jaws of the chuck are deeper than the thickness of the piece of material, we place a parallel behind each piece so that it may be held with the unfinished surface projecting beyond the ends of the jaws. We remove the parallel, bring our tool up to the face of the material, and take several facing cuts as described above. A carriage stop is fastened to the bed and set so that the stop may restrict the carriage travel. To determine the position of the carriage stop, a finished piece of work is placed in the chuck with the parallel behind it, and the tool brought in contact with the face of the material. The carriage stop is then slid along the bed until it touches the carriage. This will assure the thickness of the discs to be machined.

At this point, we usually remove the bed stop, the tool, and the tool post assembly, and ask the student to properly set up his machine in the same manner as when he did the facing operation. This will give some measure of how well he understands the centering of the cutting tool, the principle of facing, and the use of a carriage stop.

Peripheral Turning

Each of the 20 faced discs will be mounted on a $\frac{1}{4}$-inch arbor which is held in a chuck or collet. A nut is screwed on the end of the arbor to hold the disc in place. Using a right-hand turning tool, we take a light peripheral cut from the o.d. of the disc to clean off the oxidized aluminum. In order to assure a good finish, we utilize the power longitudinal feed of the machine. The operating sequence is as follows:

1. Advance the cross-feed until the tool touches the surface of the material.
2. Turn the longitudinal feed to the right until the tool clears the piece held in the arbor.
3. With the cross-feed, advance the tool .008 inch or 5 minutes on the crank clockwise.
4. Turn on the switch, engage the clutch lever, and listen for the tool to start cutting the material. By listening, we know when the tool stops cutting.
5. Disengage the clutch, turn off the machine, and remove the disc from the arbor.

We then turn the longitudinal feed to the right till it has well cleared the end of the arbor, and place a new piece on the arbor. Since the cross-feed has not been moved, we are ready to machine the second disc. Move the longitudinal feed to the left until it is close to the work, turn on the switch, engage the clutch, and repeat the operation.

Boring

Ten of the discs which have been faced on both sides are set aside for a second operation. We will place each one of them in turn into the three-jaw universal chuck, and enlarge the $\frac{1}{4}$-inch hole in the center to $\frac{9}{16}$ inch. Since it is not advisable to increase this hole from $\frac{1}{4}$ inch to $\frac{9}{16}$ inch in one step, we will introduce progressive drilling. That is, we give the student a $\frac{3}{8}$-inch, a $\frac{1}{2}$-inch, and a $\frac{9}{16}$-inch twist drill, and explain the need to drill the hole using a larger drill each time until the specified diameter is attained. We then teach the client to mount a small boring bar in the tool post and set a carriage stop $\frac{1}{4}$ inch back from the surface of the disc held in the chuck. To set the carriage stop, we touch the boring bar to the face of the material and place a $\frac{1}{4}$-inch tool bit between the carriage and the stop. This will allow us to bore the $\frac{9}{16}$-inch hole larger to a depth of $\frac{1}{4}$ inch. We require that the i.d. of the bored section be 1 inch in diameter ± .002 inch. We supply the operator with a go/no-go gauge to check this fit.

Turning to Shoulder with Given Diameters

Our next project is to turn a piece of 1-inch round bar stock, $3\frac{1}{4}$ inches long, to four diameters holding given shoulders. The piece will be held in a collet or chuck with a little more than 2 inches projecting toward the tailstock. A right-hand cutting tool will be placed in the tool post with which the work will be turned to a shoulder one inch from the end of the work to a diameter of .381 inch. The second step will be again 1 inch further at .625 inch. The opposite end of the piece will be machined after these two shoulders are completed.

Time will now be taken to teach the student how to use and read the micrometer. He will then be instructed to set the carriage stop 2 inches from the end of the piece of work and start to take off successive cuts of approximately .025 inch or one-quarter of a turn on the cross-feed. We will use the Clic-O-Matic rule or a sample piece of work as a measure to set the stop. Since the diameter toward which we are working is .625 inch and the piece of stock is 1 inch, the difference is .375 inch. If we advance our tool by .025 inch and the work is rotating, we actually reduce the diameter of the work by .050 inch each cut. Consequently, after approximately six cuts of .025 inch each we can begin to "mike" our material. Our reading should be somewhere in the vicinity of .700 inch. We then work in small steps, approaching .625 inch and taking micrometer readings at each step, until we are very close to the prescribed diameter. As already mentioned, the first inch of stock is to be turned down to a diameter of .381 inch; therefore, we can take some experimental cuts on the end of the material until our micrometer reads exactly .625 inch, engage the power feed, and run the tool all the way to the 2-inch shoulder. This technique allows some room for error since if we go in too far we can back out with the tool and make adjustments until it is cutting at a .625 inch diameter. Any marks or scratches on the first inch of the work will be removed when we reduce this to .381 inch. This operation completed, the work is turned around and placed into either a ⅝-inch collet or a three-jaw universal chuck and the opposite end of the piece reduced to .531 for a distance of ½ inch. A very light cut is taken off the remaining 1-inch diameter just to clean it up and our part is completed. We require the student to complete three of these turned parts to within ± .002 inch before we consider that he has attained a satisfactory degree of skill on this operation on the lathe and the use of the micrometer.

Making a Die Holder

In order to utilize the already acquired skills, and to add new ones, we developed a project of making a die holder. This consists of a piece of material 1¼ inches in diameter and approximately 3¾ inches long. The student is required to face both ends of the piece to a length of 3½ inches. He will need to drill one end 1¼ inches deep to an i.d. of ¾ inch. He will then place a boring bar in the tool holder and bore a hole ⅜ inch deep to an i.d. of 1 inch to accommodate a 1-inch by ⅜-inch threading die. Naturally, we will use the die itself as a gauge. The piece is then turned in the chuck, allowing approximately 2 inches to project beyond the jaws. For a distance of 1½ inches from the end, we reduce the diameter to ¾ inch or .750 inch. The piece is again turned and approximately 1 inch of the ¾-inch diameter is placed in the chuck and locked up firmly. We then loosen the compound and swing it approximately to 4:30 o'clock (or 45 degrees). We will now take a series of angular cuts with the compound, cleaning off the shoulder until the two surfaces are joined with a 45 degree chamfer. A setscrew hole will be drilled to hold the die in the cavity, and two larger holes will be drilled about ¾ inch back from the cavity end of the holder to permit chips to fall out.

Marking for the holes becomes our next operation. The piece is left in the lathe following the chamfering operation, and we touch a turning tool to the face of the piece. Then taking a piece of $\frac{3}{4}$-inch stock, and holding it between the carriage and the carriage stop, we adjust and lock the stop in position. We then turn back on the cross-feed, move the carriage till it touches the stop, turn the machine on, and scribe a light line around the periphery of the piece. This will be $\frac{3}{4}$ inch from the end. We leave the tool in contact with the material and turn the longitudinal feed to the right. This will scribe an axial line to the end of the work. We again touch the tool to the face of the part, and place a $\frac{3}{16}$-inch thick piece of material between the carriage and carriage stop, slide the stop into position and lock it in place. We can now turn back the cross-feed, move the carriage until it contacts the stop, and scribe a peripheral line around the piece. Where the circular lines and the axial lines cross, we will center punch the piece after removing it from the lathe, clamp it in the drill press vise, and then drill the required holes. On the line $\frac{3}{4}$ inch back from the end of the work we drill a $\frac{1}{2}$-inch hole. The smaller hole will be drilled on the line $\frac{3}{16}$ inch back from the edge with a #29 twist drill. We will then thread this hole with an 8-32 tap. The piece is put back into the lathe held by the $\frac{3}{4}$-inch stem and a light peripheral cut is taken to remove the layout lines. Naturally, thread series, pitches, diameters, and other technical terms will be discussed and the reasons for them explained. The drill series (numbers, letters, and fractions) and the reasons for their existence are also covered.

Preparing Gear Blanks and Cutting a Gear

Ten $2\frac{1}{2}$-inch pieces from rectangular aluminum stock $2\frac{1}{2}$ inches by $\frac{1}{2}$ inch are cut with a power hack saw. The resulting squares are placed in a jig on a drill press and drilled in the center with a $\frac{1}{2}$-inch twist drill. (If a person has a good deal of facility, he will scribe diagonal lines on the square, center punch, and drill the center hold without using a jig.) Next, we cut the corners off with either a metal cutting band saw or a hand hack saw, leaving an octagon-shaped piece of aluminum. This piece is mounted on an arbor in the lathe and turned down until it is round. The piece is turned to a diameter of 2.083 inches, and a 3-inch micrometer is used to measure the piece. The piece is then positioned in a three-jaw universal chuck, using the outside jaws, and faced off. We then turn the compound to approximately 20 degrees to the center line of the lathe, and place the tool in the tool post in line with the compound. Using the cross-feed, we move the tool $2\frac{1}{2}$ turns from the outside edge of the disc, which is held in the chuck, and advance the tool with the compound approximately .050

inch or a half-turn into the work. We then advance our cross-feed 2½ turns or ¼ inch, cutting a boss in the flat surface of the gear blank. The blank is turned over and the procedure repeated to cut a similar boss in the opposite side. When we have completed ten blanks in this fashion, we take them to an indexing head mounted on the table of a horizontal milling machine equipped with a gear hob.

Cutting A #3 Morse Taper Shank

Another project covered in our shop is the cutting of a #3 Morse taper shank. We take a 7-inch long piece of stock, 1¼ inches in diameter, and face and center drill both ends. We then turn one end of the piece, back 1 inch from the end, down to a diameter of .500 inch. This shank is threaded with a ½-inch/20 die. We remove the piece and go into the secondary operation. We take a piece of ¾-inch round aluminum stock, approximately ¾ inch long, face the ends, and drill completely through it with a #29/64 twist drill. Holding a tap in the tailstock, and allowing it to slide along freely with the bed, we thread the center hole, using the ½-inch/20 tap. While tapping, the lathe is run at its slowest possible speed. This threaded sleeve will screw onto the shank prepared on the 7-inch piece of stock.

We then set up the lathe with faceplate and centers, put the dog drive on the ¾-inch round nut which we have just prepared, and place the piece between centers. We put a standard right-hand turning tool in the lathe and turn the periphery of the piece from the tailstock, to within approximately ⅜ inch from the headstock end of the piece on which we are working, to a diameter of 1 inch. On the tailstock end of the piece, we will turn a shank down for a ¾-inch length to a diameter of .625 inch. This will allow room for the tool when we begin to taper turn.

We are now ready for taper turning, which is done with a sine bar attachment. Our South Bend ten-inch lathe is equipped with a sine bar or taper attachment. This attachment is mounted behind the bed in such a way that it may be set at a given angle to the bed of the lathe. The cross slide of the lathe is fastened to it, thus forcing the tool to ride at an angle in relation to the center line of the machine. Using this equipment, a taper is relatively easy to cut. A #3 Morse taper has a diameter at the large end of .938 inch and a diameter at the smaller end of .778 inch. We will continue taking taper cuts until the smaller end of the taper is .778 inch. If the sine bar is correctly set 3$\frac{3}{16}$ inches from the smaller end, the diameter should measure .938 inch. A #3 Morse taper socket is used to check the taper.

We then disconnect the sine bar attachment and proceed to turn the shank to $\frac{7}{8}$ inch in diameter from the large end of the taper plug, to the flange adjacent to the threaded shank on which the nut and the dog are fastened.

Additional Lathe Work

To improve techniques of turning between centers and of measuring accurately, we take a piece of bar stock a little over 7 inches long and $1\frac{3}{8}$ inches in diameter, hold it in a three-jaw universal chuck, and face the ends until the piece is exactly 7 inches long. We are going to turn this piece of stock with six 1-inch long by $\frac{3}{4}$-inch diameter sections separated by flanges .200 inch thick and approximately 1.375 inches in diameter. We turn both ends of the piece for one inch to $\frac{3}{4}$ inch in diameter, using the chuck as a holder. We then remove the chuck, replace it with a faceplate, dog, and centers, fit the dog on the $\frac{3}{4}$-inch turned end and put the material in the machine between centers. Our task is now to divide the center of the piece into four 1-inch sections with five flanges of .200 inch separating them.

There are many ways in which this piece may be accurately machined. A method which we generally use is to take the compound of the lathe and turn it parallel with the bed. We turn the compound feed counterclockwise to its extremity and, using the cross-feed and the longitudinal feed, bring the tool just in contact with the face of the already turned shoulder. We turn the cross-feed counterclockwise until the tool clears the edge of the work, and advance the compound feed in a clockwise direction $11\frac{3}{4}$ turns. This will move the tool 1.175 inches from the first face. At this point, using the cross-feed, we scribe a line on the work. We then remove the piece from the lathe, fasten the dog on the opposite end, and repeat the process. We will now place a carriage stop on the bed of the lathe, set it against the carriage, and lock it in position. Using the longitudinal feed and the cross-feed, we proceed to remove material, working from approximately the center of the marked-off portion to our carriage stop and reducing the material to something close to $\frac{7}{8}$ inch. We can turn the piece of work around and repeat the process. We have now started to remove material on the two end portions between the prescribed flanges. As in the first operation, we will back off the compound feed to its extreme, bring the tool in contact with the shoulder which we have recently worked to, back off the cross-feed till the tool clears the work, and advance the compound 12 turns or 1.200 inches, and scribe a line on the work using the cross-feed.

We may now take the piece from the lathe and turn it end for end, leaving our tool in the same position longitudinally with the cross-feed scribing a line. If our previous work has been accurate this will leave the center flange of the five flanges close to .250 inch. This will allow for accurate cuts when the project is being finished. Again we will set the carriage stop and work to it, removing material between the second and third flanges. By reversing the work we will remove part of the material in all four sections between the prescribed flanges. We can now release the carriage stop.

Because of the clearance of the tool in the direction in which it cuts, we have been working only on a portion of the depressed sections between the flanges. We will now have to work on the two sections closest to the dog, and clear out the depressed portions until the distance between the two flanges is one inch. By reversing the piece we can work on all four sections in a similar manner.

Now that the piece is roughed, the final measurements are taken with micrometers, calipers, and gauges, and the piece finished to prescribed dimensions utilizing the previously acquired skills.

Such processes as threading (screw cutting), knurling, and turning of eccentrics are projects which are utilized only with people who develop a great deal of skill and who have a good understanding of lathe work.

MILLING MACHINE

The principal parts of the milling machine are explained and the workings of the feeds are taught. The various uses and the setups of the universal dividing head are explained to the student before he is permitted to cut teeth on the blank. The milling machine in our shop is used in two ways. One way involves a routine repetitive operation; the other (for students who have both mechanical ability and interest) involves setting up both the machine and the dividing head. Usually, if a student has been able to complete the lathe, sawing, and drilling procedures on the blanks, he is equipped to learn the full operation of the miller.

As on the shapers and lathes, the various feeds on the milling machine have a pitch of ten threads to the inch; thus one complete turn is equivalent to .100 inch. Once again, care is taken to demonstrate safe working methods and develop an awareness of danger areas on the milling machine.

The techniques for setting up the material are as follows. We raise the table of the miller until the center on the dividing head is high enough to line up with the mill cutter or gear hob. We move the cross-feed of the machine until the center of the dividing head lines up with the cutter. We then drop the table, mount the gear blank on the arbor, place the arbor into the dividing head, and bring the work directly under the mill cutter. Then we take a sheet of cellophane (from a package of cigarettes) and lay it over the work. With the left hand, we turn slowly the vertical table feed clockwise and slide the cellophane between the work and the cutter continuously until a slight drag is felt. We now know that the cutter is approximately .002 inch to .003 inch above the work (for cigarette cellophane is .002 inch to .003 inch thick). With the table feed crank we draw the work back and raise it about .085 inch (or 50 minutes on the clock). The machine is then turned on and the work is advanced, allowing the cutter to mill a groove in the gear blank. Using the table feed, the work is returned to its original position. The dividing head is indexed, setting the work for its second cut. This process is repeated 48 times to complete the gear. By checking the curvature at the end of the gear tooth, we can readily find the depth of the cut and increase it if necessary. From this point on the cutting of gears is strictly a routine repetitive operation.

In all of the operations which have been described, scale samples are shown to the student to familiarize him with the necessary nomenclature prior to his embarking upon any project.

DEVELOPMENT IN VOCATIONAL AIDS: ENGLAND—PART I

CEDRIC W. GARLAND
Royal National Institute for the Blind, London, England

This paper is a joint presentation on behalf of St. Dunstan's, London, whose research is directed primarily toward the benefit of the British war blinded, many of whom have additional disabilities; and of the Royal National Institute for the Blind (RNIB), London, whose technical developments are concerned with the 120,000 British civilian blind. Certain aspects of the work of these two national organizations are interrelated, particularly in technical research.

It is not intended to present details of long established techniques and apparatus which are generally well known, but to concentrate on recent vocational technical developments in educational, industrial, and domestic fields, including projects at present in an embryo stage, together with mention of related work which it is considered will be of international interest.

The first section of this paper is presented by the Royal National Institute for the Blind.

Investigation is presently being carried out in the development of a doorbell or door knocker equivalent, to indicate to deaf-blind people that a caller is at the entrance of their residence.

Various methods of achieving this have been considered, including the use of electric fans to create air movement, scent sprays for aromatic indication, pocket buzzers, and furniture or building fabric vibrators. These and other mechanical methods suffer from various drawbacks.

The most promising method, now in an early stage of development, consists of wiring the premises with an induction loop fed from a transmitter switched from a doorbell push, to generate within the habitable area a frequency induction field (of 40 kc/sec with a carrier wave modulated at 300 to 400 cps).

A small pocket receiver worn by the deaf-blind person feeds a miniature bone conductor transducer which, when placed in contact with a sensitive skin area, indicates the presence of a caller by mechanical vibration. The apparatus would be fully transistorized to render it lightweight.

This equipment has been tested on the deaf-blind and has proved very effective when the transducer is placed in a highly sensitive area such as the finger tips. However the user should ideally wear this on some convenient place such as the arm or leg which happens to be relatively insensitive. As yet sufficient amplitude of vibration at the transducer has not been obtained for detection on these parts of the body.

This deficiency in amplitude of vibration is due to the limitation in power of the induction field imposed by the General Post Office induction communication regulations in Britain. It is expected that further experiments with various types of transducers and possibly remote induction switching of an independently powered circuit will shortly produce a satisfactory output.

Such apparatus has been long required by deaf-blind people and it may also be possible to extend the system to include both house and garden to give the user a greater degree of freedom and independence. It is also considered suitable for application to separate flats within a building using differently modulated carrier frequencies so that any overlapping of adjacent induction fields will affect no other receiver than the one tuned to it. This has still to be substantiated by test, but it is expected that a reasonably priced unit will be soon available not only for the deaf-blind, but also for the deaf who often tend to discard their normal hearing aid when at home.

Of further interest to the deaf-blind is a new conversation machine now being produced in England. No knowledge of braille is required by the sighted person who rotates a dial to the letter or number required and depresses a key to raise six pins in braille character form. The message can be conveyed to the deaf-blind reader in two ways; firstly by placing the reading finger directly above the pins to read the braille characters as they rise, and secondly by means of an embossed 16 mm film strip on which the complete message can be written and the strip cut off and passed to the reader.

This machine is considered to be a useful development in deaf-blind conversational apparatus, as it can also emboss a permanent message which separates the speed of the writer from the speed of the reader, a most useful feature as many writers tend to operate the machine too quickly for the reader. Known as the ARCAID machine it is available from the RNIB at a cost of £51.0. ($142.80).

In cooperation with the RNIB, Mullard Research Laboratories have produced a design for an Acoustic Lamp Reader to enable blind operators to monitor the indicator lamps on the newer types of light-signaling telephone switchboards. The device, intended for use on private branch exchanges of the Post Office (PABXI type), uses a photoelectric cell, a transistor oscillator, and a loudspeaker to convert the light output from the signal lamps to an audible tone, and can be fitted without modification to the switchboard.

The photocell is mounted on a small carriage which is attached magnetically to metal rails already existing on the board facia. When the carriage is moved by hand along the rails the photocell passes over each signal lamp in turn, and any active lamp causes the cell to respond, producing a tone from the loudspeaker. The blind operator can thus locate any line needing attention, and determine the state of the board at any moment without interrupting the traffic. The operator is warned when the board requires some action by a single audible alarm which is a standard item of the board's equipment.

The carriage is moved with one hand, and since it is firmly attached to the rails the same hand can be used for manipulating the appropriate keys or switches. Meanwhile, the cell remains over the lamp, monitoring the action taken by the operator. The Reader responds to both steady and flashing signals modulated to 2.5 cps, producing steady and interrupted tones.

The transistor oscillator and loudspeaker are housed together with the small 9-volt dry battery in a separate unit measuring 6 inches by 4 inches by 2 inches and connected to the photocell carriage by a flexible lead. Due to the low power consumption of the oscillator and the photocell (one of the latest high sensitivity cadmium sulphide types) the battery life is expected to be more than six months.

This device is in itself a means of full time employment for a blind person and is an example of the type of equipment that can be produced today in a compact transistorized form for monitoring visual systems using illuminated indicators.

A more conventional approach to this problem of the operation of PABXI Boards is also in use as an alternative to the Mullard reader. This consists of mounting the switchboard on a low plinthe containing doll's-eye drop indicators wired direct to operate with the signal lamps.

An example of a recently introduced standard commercial product of use to the blind is that of a simple pocket-sized circuit tester which consists of a transistorized audio oscillator powered by a dry battery.

This instrument gives a clear audible signal on circuits up to 47 kΩ resistance, with variation in pitch at different resistance values. The low short circuit current of 15 ma enables the directions of current flow through transistors and diodes to be verified without risk of causing damage.

The particular instrument referred to is the Swiss-made CIRTEST circuit tester which has been in use by a blind operative at the Bush Radio Corporation in England for some weeks, and has proved very satisfactory for continuity tests where precise measurements are not required. Other similar instruments are being manufactured but the CIRTEST meter is the most satisfactory of those examined. It is available in London at a cost of £3.10.0 ($9.80) and is considered to be a useful aid to the possible employment of the blind in the growing electronics industry.

A recent development in the presentation of detail on maps for the blind is shortly to become available in the form of a map of Europe, the first of a series to include the representation of geographical features by graduation of surface textures. It is proposed that complementary physical and political maps of each region selected be produced with a joint braille instructional guide. The existence of two maps will enable fairly comprehensive coverage in abbreviated braille symbol form without the congestion that would result with only one map.

The maps are vacuum formed in a rigid polyvinyl (PVC) sheeting .010 inch thick and the selection of textures is such that reproduction can be made in this material with a consistent degree of definition. These maps will also be printed in color in tones of sufficient contrast to facilitate their use by the partially sighted. The thermoplastic sheeting used must be largely free from residual calendering strains so that good register control can be maintained during vacuum forming.

The main problems of producing vacuum formed textures have been in mold construction—in providing adequate ventilation for mold surface evacuation to ensure that the plastic is not restricted from taking up the definition required (particularly of the fine textures), and at the same time being able to correct mold errors. Experiments have shown that sintered metal sheeting is ideally suited to vacuum forming due to its overall porosity, and its tensile strength capable of withstanding, with simple mechanical support, the repeated stressing imposed by the vacuum in continuous production. The material in use at present is a sintered bronze which is not subject to corrosion and can be machined to suit the textures required with conventional high speed steel engraving tools without affecting the porosity. It can be obtained in a range of particle grades having smooth or rough surfaces which can be used as one map texture, the remainder being machined into or built up on the surface by metal or resin overlays.

The requirements of the textures selected is that they must be readily differentiated and those utilized on the physical map of Europe range from fine to bold surface representation of altitude contours. They have been selected after considerable consultation with schools for the blind of various educational levels and the general reaction is very favorable as the detail under the fingers is immediately informative in a way unobtainable with relief maps involving scale representation of the third dimension.

In the field of writing equipment a new upward braille writing machine became available in August of 1962.

This machine known as the Pyke Braille Writer provides for both interline and interpoint, selected by a quick change lever. The paper is kept flat throughout embossing, being supported on integral extensions at the front and rear of the machine. Separate paper clamps used on the previous British machine have been eliminated and the paper is now clamped and fed through the machine by rollers in the side margins, coupled by backlash-free spur gears which are positively indexed to the line feed mechanism.

Paper up to a maximum width of ten inches can be used and is positioned relative to side and front lays which are interlocked to the feed mechanism, so that if the paper is not accurately located it will not be clamped. The accuracy of this system of paper location is sufficient to enable a sheet of interpoint braille, after removal from the machine, to be reinserted for further embossing in precise alignment.

The machine has six keys, three on each side of a central space bar. These are linked to the escapement of the embossing head that traverses the machine from left to right and is returned either one character at a time by the backspacer or manually to the beginning of the line.

The embossing styles are designed in the form of six combs extending the full length of a braille line, with each comb representing one and the same dot of every character across the page. As each key is depressed, the respective comb is raised on wedges, and the single character pit plate on the embossing head then pivots downwards to emboss the character. This sequence of comb raising and embossing aims to avoid variation of dot size caused by the common defect of an operator having one or more weak fingers, as the embossing pressure is carried by any one of the keys selected. The combs are made of brass, resistant to wear and corrosion.

The machine will write 36 characters per line, 21 interline lines and 28 interpoint lines on both sides of our 13½-inch long paper. Paper of any length above 6 inches can be used, the margins being made automatically by the paper lays. Special margins are provided for by margin stops which can be adjusted for use with undersize paper or for tabulation. The right hand margin stop incorporates a warning bell which rings seven characters before the end of line and for deaf-blind users of the machine this bell has been replaced by a tactile indicator fitted into one of the three key pads on either side of the machine, these are operated by a dry battery via an adjustable contact on the margin stop and are immediately detectable on the approach to the end of line.

Braille scales are fitted to indicate the carriage position across the line and line positions for both interpoint and interline.

The machine is constructed in light alloys wherever possible and mechanical working surfaces are of hardened steel, all ferrous components are passivated against corrosion, and bearings are of bronze where applicable. Nonoxidizing lubricants have been used throughout and lubrication should not be necessary for many years.

Much attention has been paid in the design to the interchangeability of components and subassemblies so that any reasonably skilled mechanic can replace components without special fitting. This could be of particular advantage to users abroad who could carry out their own repairs with replacement components.

This interchangeability also applies to the embossed braille which is of sufficient accuracy to permit the braille from any one machine to be replaced in any other machine without adjustment. For making additions or corrections, this should be of particular interest to organizations using the services of external transcribers whose work often needs alteration.

The weight of the machine alone is approximately 18 pounds and in its case 25 pounds. The cost is £47.0 ($131.60).

A useful piece of equipment now being constructed is that of a braille typewriter for use by the RNIB editorial department in preparing advance information for external sighted transcribers who are undertaking the transcription of specialized textbooks.

The typewriter has braille character typefaces and prints visual unembossed braille—through the typewriter ribbon in the normal way—to illustrate to a transcriber how particularly difficult passages should be embossed.

This aid to braille production is expected to save many hours on the part of experienced editorial staff now spent on correcting the work of transcribers who are often unfamiliar with advanced scientific or other highly technical forms of notation. The typewriter is otherwise standard and costs about £25.0 ($70) to adapt in this way.

The need by students of chemistry for some means of color determination has stimulated investigation into the development of a simple colorimeter to suit the educational requirements of chemical analysis. At the same time it is being borne in mind that many other outlets may exist for such an instrument for use by the blind.

A general purpose prototype of one possible method of achieving this has been constructed which can be adapted to special needs within varying degrees of accuracy based on the following lines.

Light from three small lamps is incident on a transparent chopper disc rotating at 3000 rpm on which three sine wave form tracks are blacked out to give three, five, and seven dark areas per revolution. The light transmitted by the transparent areas is therefore modulated at 150, 250, and 350 cps and is then incident on a filter assembly of the three primary colors red, blue, and green. Each color transmits the light from one lamp at its respective frequency and is controllable for intensity of illumination by individual shutters on each filter.

From the filter assembly the light shines across a space in which the sample to be analyzed is placed. The light transmitted by the sample falls onto a lens which focuses it onto a barrier layer photocell coupled by a transistor amplifier to headphones in which any or all of the three modulated tones are to be heard, each tone being adjustable in volume by the shutter controlling the appropriate beam of light.

When a sample is introduced which absorbs one color preferentially, the tone corresponding to that color will be diminished more than those of the other two colors and it has been established by tests that a color can be identified by a skilled blind operator by noting the change in relative levels of the three tones.

The discrimination of color with this device is essentially subjective in the same way that visual discrimination is subjective. Furthermore various filter materials may not correspond exactly to the spectral sensitivity of the color receptors in the eye, and there could be occasional differences between the visual color descriptions and those obtained using this device. These are analogous to the visual appreciation of turquoise when viewed against blue and green backgrounds.

The accuracy of this instrument will of course be directly related to the quality of the filters used, and for special purposes the use of special filters could be considered, for instance for blind diabetics using the clinitest method of color determination of sugar concentration in the urine.

Before proceeding further with this instrument various other designs are being considered for tactile as opposed to audible indication, and for the ability to deal with both reflected and transmitted light from the sample. From preliminary tests it would seem that color measuring equipment in compact and inexpensive form is a practical proposition for the blind as an aid to education and has possibilities as a means of employment.

The age-old problem of a playing ball for blind children has been taken a stage further by the introduction of an Audible Playing Ball which incorporates an internal sound unit comprised of a transistor oscillator with diametrically opposed Rochelle salt crystal microphones used as transducers. An intermittent tone is emitted by the unit which is powered from a mercury cell having a capacity sufficient for an operating period of approximately ten hours. The cell is rechargeable from a standard dry battery.

It is felt that this development is an important one in assisting young children to develop a natural sense of orientation and proximity and it is hoped that a further application of a similar unit will enable a football to be designed along similar lines. The Audible Playing Ball can be purchased from the RNIB at a cost of £6.3.0 ($17.64).

Attention is being paid to the application of closed circuit television to the special needs of the visually impaired for the purpose of obtaining visual assistance when dealing with correspondence, documents, objects, etc. In the first instance, in all probability, the RNIB will provide the service through GPO lines. It is hoped that should the demand warrant the GPO, who have agreed to cooperate with the experiment, will then man such exchanges as are set up.

Conventional systems using coaxial cable circuits with wide bandwidth transmission requirements are extremely expensive and would preclude the use of television at the present time.

By slowing down the scanning rate by approximately 1000 times, the frequency band may be reduced to a degree which allows transmission by conventional 3 kc/sec telephone speech circuits which can be rented economically, and from tests carried out at the RNIB using coaxial lines, it has been established that such a service would be both practical and invaluable for the blind in having a letter or document read, or being guided for writing a signature by a sighted observer at a remote monitor screen.

Little useful detail can be given at this stage of commercial research into the equipment for slow-scan techniques. Work now in progress at a number of companies is aimed at using normal closed circuit cameras, converting to slow-scan standards for telephone line transmission for storage display on a monitor screen for sufficient time to give the impression of a continuous image or, alternatively, reconverting to high speed scanning on standard receiving type tubes.

Research in this field is advancing so rapidly today that it is hoped that a workable and economic system will materialize in the very near future. When this has been achieved it does not require much imagination to foresee the potentialities of the system in the world of blind welfare.

DEVELOPMENT IN VOCATIONAL AIDS: ENGLAND—PART II

RICHARD DUFTON
St. Dunstan's, London, England

PRECISION MEASURING INSTRUMENTS

Before adapted precision measuring instruments were available, blind inspectors in open industry were already familiar with some of the standard equipment used by sighted workers. The micrometer caliper is the most precise and the most commonly used hand measuring tool in the engineering workshop. It is not surprising that in the mid-nineteen forties, this was the first tool to be adapted in an endeavor to extend the scope of the blind inspector in open industry.

Micrometer Caliper

As you know, the micrometer caliper depends on the contact principle, two parallel hardened surfaces being employed. One, the anvil, is fixed to the frame, while the other is made adjustable by means of an accurately cut fine pitch nut and screw. The visual linear scales on a standard micrometer have been augmented by braille scales around the circumferences of two enlarged rotatable drums. A third stationary drum is provided with a raised datum line. Braille numerals and subdivisions on the two rotatable drums are checked against this datum when taking a measurement. A short vernier scale is embossed just below the raised datum line, permitting a direct reading accuracy of .0002 inches. Proper use of a micrometer usually involves some method of ensuring that the pressure between the measuring contact surfaces is kept within reasonable limits.

In training, an inspector has to develop a "feel," since the mechanical advantage resulting from such a low geared transmission can result in excessive pressure between the faces and the work piece. This is especially important since the ratchet stop or slipping clutch device, common on many sighted micrometers, has not been incorporated in these particular adaptations. While there is a 2-inch version of this instrument, the 2- to 6-inch micrometer caliper, which has the same order of precision, is described here.

The measuring head is identical with the previous instrument but interchangeable anvils, in one-inch increments, are provided; we are only concerned with measuring the last inch to high precision. A set of check gauges ensures that on fitting any one of the four anvils, the instrument is zeroing correctly. This adds to the cost of the tool, but the accuracy achieved is indeed remarkable when considering the wide rage of engineering components that can be measured. Further evidence of the sensitivity of this precision tool is provided by the fact that the four check gauges are fitted with rubber insulating sleeves to eliminate thermal expansion effects when handling the gauge.

Micrometer Depth Gauge

This is the third example of a standard instrument adapted to have a braille output. The measuring head is mounted on a base which forms a reference plane, with provision for inserting measuring rods through the center of the assembly. A set of rods, in one-inch increments, permits gauging holes up to six inches deep. In the case of small diameter bores the tool is often the only one that can be employed with this order of amplification. In the selection of the appropriate probe the blind operator's task is facilitated by the provision of milled flats, or segmental shaped forms, on the rear stop collar of each rod.

Precision Caliper Gauge

Generally, the vernier caliper may be regarded as the first step in the attempt to obtain more uniform and accurate readings than are possible with ordinary calipers and steel rules. This adapted instrument has a range of 0 to 10 inches in increments of .001 inch. As is the case with standard vernier calipers, internal diameters of shallow depth can be measured by means of stepped portions on the measuring jaws. The beam is calibrated in inches, by means of milled slots, thus enabling a reading to the nearest inch to be made in the first instance. The sliding jaw also has ten hinged gauge blocks, pivoted on a common axis. These blocks are exactly 0.1 inch in thickness, and pivot through 90 degrees. The second sliding head, incorporating a serrated disc and an integrally mounted gauging spindle, is advanced towards the measuring jaw and then retracted until the head engages in the foremost milled slot of the beam and is clamped in position by means of a setscrew. A distance of less than an inch now obtains between the measuring jaw and the extremity of the gauging spindle, and the maximum number of gauge blocks is pivoted into the gap and counted. We now have determined the dimension to 0.1 inch. The disc is calibrated to .001 inch by means of serrations around its periphery, and these engage with a spring ratchet stop. Audible clicks indicate an axial movement of the measuring probe of .001 inch as the disc is rotated and the spindle advances to make contact with the pivoted gauge blocks.

Braille Bevel Protractor

A useful bevel protractor enables angles to be measured with a high degree of precision. It has the usual adjustable blade and fixed stock. Any given angle may be determined on the embossed braille scales, which are graduated in degrees, from 0 to 90 each way. The adjustable blade can be clamped in any position while the measurement is taken against the raised datum line. It reads to one-quarter of a degree, that is, 15 minutes of arc.

Dimension Indicator

When a series of dimensions have to be checked against a machine drawing, we sometimes employ a device called a dimension indicator which permits a sighted person to preset dimensions for a blind inspector. Up to ten dimensions in sequence can be handled on this device which has both sighted and braille numerals on rotatable square section blocks, housed in ten hinged sleeves. The embossed rotatable blocks, preset to indicate the dimension, are locked by means of a screw.

Vernier Rule

This is an instrument with a range of 0 to 6 inches and an accuracy of .0025 inch. While simpler in design, it is versatile and permits the checking of external and internal dimensions. In addition, depths up to six inches can be measured.

Tabular Information

Most sighted engineering inspectors make frequent reference to tabular data, and our adaptation here is to braille the information directly onto thin zinc plates. The data comprises tables of drill and screw thread sizes, metric conversions, decimal equivalents of fractions, etc.

Most of the adaptations we have considered so far depend on the "feel" method, where the measuring contacts just slide over the work without play, but also without undue tightness. Here the blind operator is at no disadvantage, with his natural aptitude in operating tactile systems.

Comparators

The instruments so far described are used to ensure correct assembly and interchangeability of machined engineering components. For higher rates in repetitive production, there is a class of instrument generally called comparators. These are being used more and more by our inspectors in industry.

Comparators check and amplify small dimensional variations on the workpiece, a pointer reading usually observed on a scale. Many, however, employ a system of flashing colored lights to signal "pass," "reject," etc., and it was logical to adapt them to give an auditory output. The operator usually wears earphones, and there is a good deal of evidence to show that the ear has greater acuity than the eye, where indicating or alarm signals are involved. Machined components are fed either mechanically or by hand to the measuring elements. Foot pedal operation is sometimes used to eject the work, cancel an electric signal, or to actuate the gauging element.

Comparators which have been modified to audio output include mechanical linkage types, electric contact, electronic circuit, pneumatic, and manometric/pneumatic. Obviously a shorter period of instruction would suffice for a blind operator to operate equipment adapted in this manner. Good coordination is required where hand loading and foot pedal operation are combined in one instrument.

In the explosive growth of the electronics industry, resistors, capacitors, and other components are now required in millions. An electronic component comparator, which we have recently investigated, is capable of control by a blind operator. It has a specially designed moving coil meter, which makes possible test speeds of up to 3000 components per hour. The instrument compares the component under test with a standard unit and directly indicates the percentage deviation. The usual three-color light indicator can be replaced by three sound generators, having distinctive frequencies.

Another interesting instrument also capable of testing resistors, capacitors, chokes, and miniature multiwinding transformers, may be modified to give a tactile display as an alternative to ten sequential light signals. In its original form as a transformer tester, inspection times were reduced from seven minutes (manual test), to half a minute for a series of four basic operations carried out automatically in sequence. Adaptation to a tactile, ten-pin display is feasible, failure on any one test being indicated by the appropriate pin rising above the nominal pass position.

OTHER DEVELOPMENTS

Turning now to the production side of industry, adaptations have been made to a variety of machine tools. They include feed indicators on capstan lathes, milling machines, and gear hobbers. On some special purpose machines, e.g., gear hobbers, for long machining cycle times, it can be an advantage to install an indicator to keep the operator informed of the progress. This recognizes that there can be a basic difference between a short cycle machining sequence and the lack of any pacing aid on machines where the cycle time may run into several minutes.

St. Dunstan's has made a special study of the needs of men and women doubly handicapped by the loss of hands as well as sight. A typewriter has been adapted for those so disabled by fitting a light alloy cover consisting of a series of terraces coinciding with each bank of keys. Each terrace has holes in line with the keys, which are depressed by a metal finger located in the gauntlet socket. The required key is found by counting along the appropriate terrace and then depressed by the metal finger, bent at right angles. Great concentration is required to operate this system.

A dispenser holding 25 cigarettes displaces a cigarette into a vertical position when a plunger is pressed. The dispenser incorporates a battery-powered heating element automatically switched on as the cigarette is exposed. The smoker takes the cigarette in his lips and withdraws it after ignition. A warning buzzer emits an audible signal when the last cigarette is removed.

A repeater watch and a clock have also been adapted. On depressing a plunger the time is indicated by chimes. Spring damping is provided between the plastic operating plunger and the watch mechanism to prevent inadvertent damage to the instrument. The pocket version weighs seven ounces.

An automatic GPO telephone switchboard has been adapted for handless operators by combining foot pedal switching with metal probe operation of push buttons. Ten exchange lines and 50 extensions can be handled on this board which is installed at our headquarters in London.

Recreational pursuits have been the subject of several interesting adaptations and one of the most successful is an electronic rifle on a miniature 15-yard range. It is mounted on a swivel stand and maximum safety protection is afforded by the fact that it is constrained to fire only in the five-foot bullet trap area.

At a point near the front sight a screened circular metal ring 2½ inches in diameter surrounds the barrel. The ring is wired to one side of a twin Franklyn beat frequency oscillator which is tuned to about 650 kc/sec. The barrel is connected to the other side of the oscillator and beats against the tuned oscillator. When the rifle is trained on the bull, the marksman hears a very low note. Increasing deviation, either in bearing or elevation from the center of the target, is indicated by an increase in frequency, either through loudspeaker or earphones. The marksman is thus able to achieve a high degree of accuracy. Further research is in hand towards enabling the deaf-blind to fire the rifle which is a standard .22 gauge miniature range type.

There are the well known adaptations to indoor games, such as playing cards, dominoes, chess, and darts, to mention a few. Some outdoor recreational pursuits require little or no modification for the blind man.

An interesting adaptation of the "paging" or intercommunication system, as installed in hospitals and commercial establishments, is made by means of an induction loop and a miniature tuned receiver giving audible signals. This has already given promising results in an outdoor environment and further experimental study is in prospect for both recreational and general guidance needs.

To enable technologists to continue in specialized occupations, a series of electric and electronic meters have been adapted. Their scales have been brailled and, in most cases, values of resistance, capacitance, or inductance are taken when the balance point is signalled by loudspeaker or via earphones. Included in this category is a teleprint tape transcriber, for which a standard tape reader has been adapted to give an embossed code on a modified braille shorthand machine.

There are several encouraging trends which may widen the range of vocations open to the blind. In Britain a considerably extended range of scientific works on physics, electronics, and chemistry will become available with the recent publication of a new Braille Science Notation. With the recent extension of recorded information on the cassette and other magnetic tape systems, study facilities are growing. Adaptations to programmed teaching machines, with their special feature of self-pacing, may find a place. New vocations that might be considered are applied metallurgy, radio monitoring, or machine programming, among others.

DEVELOPMENTS IN VOCATIONAL AIDS: SWEDEN

ANDERS E. ARNÖR
De Blindas Förening, Stockholm, Sweden

Our times are revolutionary times. Revolutions occur first of all in the technical sphere. Some inventions create undreamed of possibilities for the human race, while others are apt to frighten us, owing to their destructive effect.

Today blind people throughout the world cherish the hope that technical devices will be invented which will solve their problems. This is true in Sweden no less than in other countries. Sweden is a small country, with a population of about seven and one-half million. We do not yet know the exact number of the blind and partially sighted, but their number would seem to reach about ten thousand people, or one and one-half per thousand of the population.

Thus in Sweden the blind form a very small group in a small country. This means that the market for special technical devices for the blind is exceedingly limited. It is easy to understand that the industries which must produce articles in large quantities cannot cater to such a small group, especially since its purchasing power too, is small.

The development and manufacture of our devices require considerable financial resources and, since these are limited, we must ask ourselves the following questions when facing a technical problem:

1. Is there a device already in use by the sighted that will solve the problem?
2. Can we, by minor modifications, make it easy for the blind to use the device?
3. Does such a special device exist in some other country?
4. If no device is available, is it technically and economically possible to produce a device?

I shall present some examples to illustrate these questions.

Example 1. When the United States stimulated us to greater interest in the talking book we tested a great many sound recorders. Subsequently, the Norwegian Tandberg tape recorder was found to meet the demand for a simple apparatus that was likely to wear well. It has now been in use for six years and may be described as the "Model T" of tape recorders in durability.

Example 2. We had some engineers and office workers who often had to make interest calculations. People with normal eyesight use a calculator for this purpose but the figures that show the results cannot be read by the blind. By removing the glass that covered the figures, widening the openings, and manufacturing wheels with braille characters, we have made these calculators as useful to the blind as to the sighted. They are now manufactured at little extra cost as part of the manufacturer's regular production. This calculator has been introduced in America by Facit, Inc.

Example 3. When, some ten years ago, we started in Sweden to train blind metal workers, we found that they needed a measuring instrument for checking their work. This problem had been solved in England, and we now buy the micrometers needed from them.

Example 4. A young laboratory worker had become blind. After rehabilitation he was to be allowed to return to his former job. His work consisted in drying earth samples from dams, power stations, etc., in a stove. Thereupon the dry earth had to be weighed, sieved, and divided into ten portions according to the size of the grain. Every sieved portion had to be weighed separately, and the percentage of each portion was to be calculated. The drying, sieving, and the resulting calculations presented no problem, but the weighing seemed an insurmountable difficulty. We had, however, just received an experimental device (a photocell, coupled to a buzzer) from the United States. This solved our problem. Mounted on a frame provided with braille characters, this photocell "saw" the black hands of the balance against the white background of the scale.

The catalogue of technical devices which can be obtained from the Association for the Blind in Sweden distinguishes among the following groups of devices:

1. Devices for everyday needs. This group includes braillewriters, typewriters, tape recorders, white canes, games, watches and clocks, thermometers, syringes for insulin injections, etc.
2. Technical devices for the home. These include coffee boilers with a level indicator, tape measures marked with braille characters, metal needle threaders, frying tongs, household scales, thermostatic irons, sewing machines with marked scales, timers, etc.
3. Devices for craftsmen, such as, fillet dividers, and clipping and finishing appliances for brushmakers.
4. Devices for other professionals, such as the shorthand writer and calculator mentioned above for office workers, micrometers and calipers for metal workers, etc.

Naturally, all these devices require accessories. The caliper deserves special mention, since it has been constructed by a former professional teacher who is blind. A caliper is used by the sighted metal worker for the rapid control of measurements with a tolerance of 0.1 mm. This caliper which has been designed for the blind has its nonary on a rotating disc which makes one revolution per cm. The periphery of the disc is divided into nine sections of equal size, which, if compared to a ten-section scale beyond the disc, marks a deviation of 0.1 mm for every section of the disc. The caliper gauge is provided with clearly marked characters, which can be read even by calloused fingers.

Even if technical devices can to some extent compensate people for their lost sight, the use of such devices always implies the mastering of a certain technique. In Sweden we have had, since 1957, two rehabilitation centers for the adult blind. These have recently been complemented by two centers with adjustment courses for the adult blind. These four institutions are situated in different parts of the country. One of them provides professional training for metal workers and punch press operators, and one teaches office workers to handle dictating machines. The main object of the adjustment courses is to teach the newly blinded the technique of the necessary special movements and to train them in the use of devices.

One often hears newly blinded people say: “I get so tired doing simple everyday things that used to be so easy.” This depends, naturally, on the strain of their muscles, even those which often need not be used. The course of instruction aims at reducing both the physical and the psychological strain as much as possible. In Sweden, we have found that the approximately 300 brushmakers have almost as many working methods as there are workers. This old profession sticks to its traditions and pays more attention to quality than to quantity. Only in exceptional cases can it support the worker. Since, however, the number of brushmakers is comparatively large, our opinion was that something should be done to make the work more profitable. Consequently, we contacted a methods engineer who conducted certain studies of the methods being used. He found that by making the worker sit properly, having the workshop equipped in the right way, and the working material in the right place, and by inducing the workers to make well balanced movements with their hands accompanied by a relaxing of other muscles, the capacity of the people who took part in the experiment could be raised by 20 percent. Furthermore, they did not get as tired after work as they had before. The brushmaker can feel as relaxed in his seat as the airplane pilot in his cabin.

The first study of suitable methods will be followed by personal instruction to every craftsman. We consider this necessary since the blind are unable to copy a process by watching a demonstration. Every movement must be taught and practiced, and the worker's position must be suited to the work at hand. In addition, workshops must be equipped to suit the new experience gained.

Our world has been adapted primarily by and for the sighted. If a device exercising all the functions of the human eye could be constructed, the blind would no longer be handicapped. We shall probably never get that far. The problems of the blind have to be solved step by step. Sweden is engaged in research, not on a very large scale, but only as far as our financial and human resources permit.

As I stated earlier, the Swedish market is too restricted to attract the manufacturer. But our industries could undertake to manufacture devices if they were assured that their products could be placed on the international market. At present we are mainly interested in two devices, i.e., an obstacle detector, and a telephone apparatus for the deaf-blind and the deaf.

If products are to be sold at a reasonable price they must either find a market that is larger than the Swedish home market, or be produced in a large country.

When one has the privilege of attending a congress where so many experts are assembled, one is naturally tempted to enumerate the devices one would like to have. I shall limit myself to naming a few which might be produced without requiring a great deal of research.

1. I have already mentioned the use of the photocell with either audible or tactile output. The examples I cited referred to only some of the fields where a photocell could be used with advantage.

In Sweden there are about 70 blind typists at work. They often experience difficulties in finding a certain line on a form or in continuing to type beyond the end of the page or line, or simply in finding out whether the ribbon is working properly. A photocell mounted on the typewriter might be able to provide this information.

2. With the introduction of automation the use of electrical measuring appliances and control lamps will increase. Many blind people devote their free time to radio telegraphy, others handle machines with meters for reading stress, resistance, and other data.

Could someone invent a device which the blind can carry in their pocket and by means of which they can take the readings of different meters?

3. We have about 20 blind persons engaged in darkroom work at the X-ray sections of hospitals and other laboratories. They look for a device that would allow them to determine the specific weight of fluids.

These devices I mention are more complex, and therefore have more appeal to us, but we must not forget to develop the small, simple devices which everybody could get and use. For my part, I hope that international cooperation in this field will become intensified, and we regard the initiative which has resulted in this congress as a brilliant beginning.

DEVELOPMENTS IN VOCATIONAL AIDS: WEST GERMANY

KARL BRITZ
Verein der blinden Geistesarbeiter, Marburg/Lahn, West Germany

Of the various technical aids blind persons are using in vocational work, those for work with the hands have been treated in several other papers. This paper is confined to aids for intellectual vocations. Most of the aids described here were developed in Germany and are proving their utility in everyday applications. Others newly developed are still being tested. Many devices for instructional and vocational purposes will be omitted as they can be assumed to be generally known.

A most useful device, which for a long time was manufactured only in Germany, is the braillewriter invented by Oskar Picht early in this century. Without changing the original design, various manufacturers have improved the apparatus and added several features during the past few decades. The machine is simply designed and of rugged construction.

Figure 1 shows it in its modern form as produced by the Blindenstudienanstalt in Marburg. The construction is similar to that of a typewriter. However, only a few keys are needed—one for each dot of the braille cell, one space bar, one backspacer, and a carriage release lever. The paper is wound on a thick cylinder. The great advantage of this instrument is that it writes positively, that is, what is being written can be read immediately and without inconvenience. The braillewriter is therefore an efficient aid for numerical and mathematical calculations, too, and it is gradually replacing the writing slate.

The braille shorthand machine was developed from the braillewriter. As can be seen from Figure 2, it is a small case measuring 8¼ inches by 5 inches by 2½ inches, including a keyboard similar to that described above—6 keys for the 6 dots and a spacing bar. Instead of a sheet it uses a paper tape. The tape is a little over ½ inch wide and about 150 feet of this tape can be stored. The braille symbols are embossed on the tape. Thus loss of time in changing lines and sheets is avoided. A highly abbreviated short-

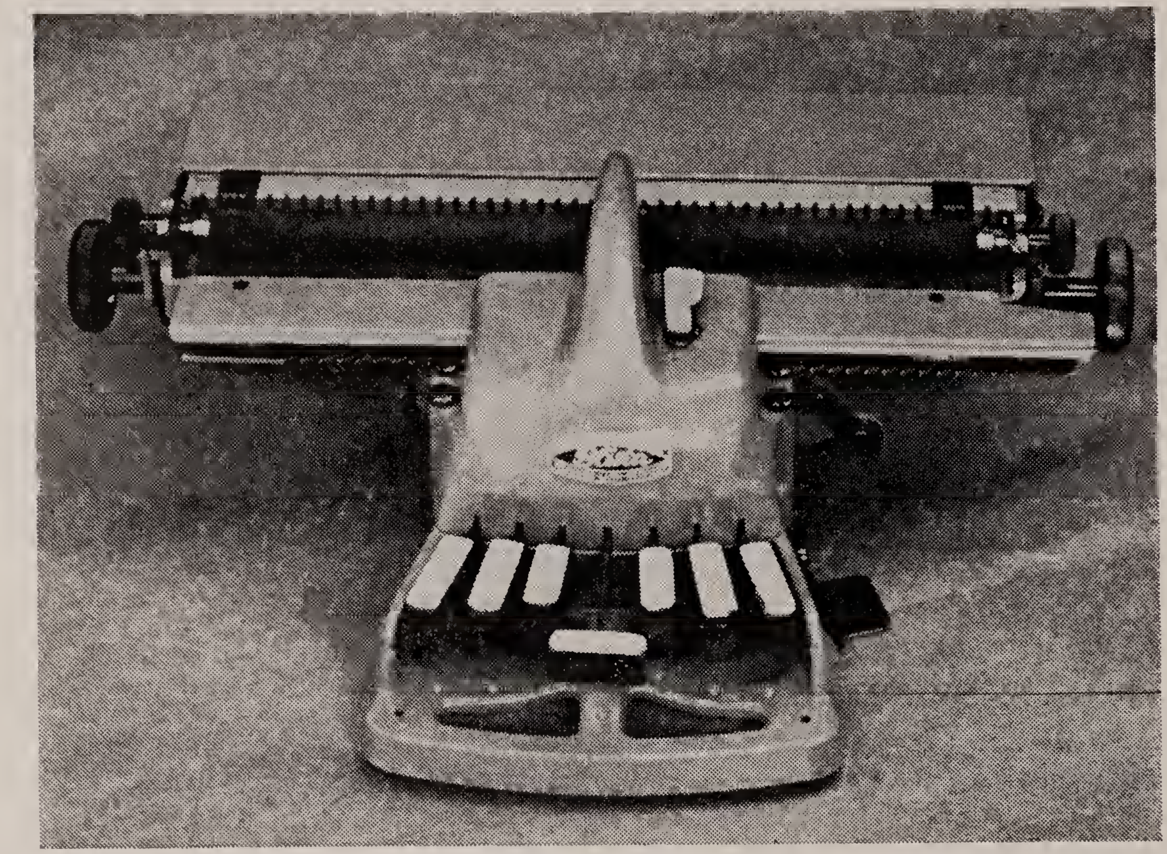

FIGURE 1 Marburg Braille Sheet Typewriter

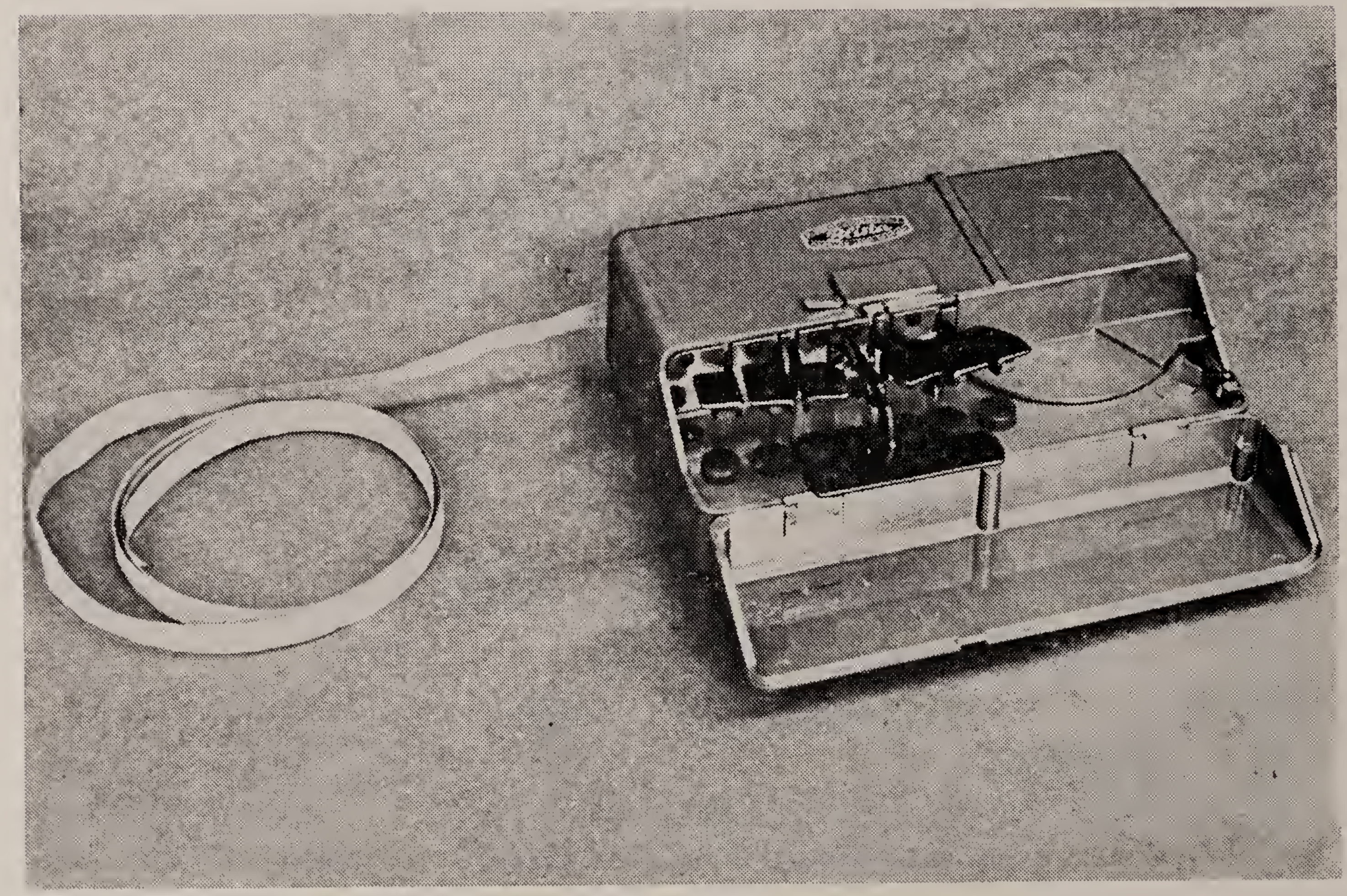

FIGURE 2 Marburg Braille Shorthand Typewriter

hand system provides high speed writing. Skilful writers can achieve 250 to 300 syllables or more a minute.

Various accessories are available, such as a device for automatic winding of the printed tape, clamps to hold and guide the tape while the shorthand report is transcribed to the typewriter (see Figure 3), a sound absorbing case, etc. A similar model is produced by another German manufacturer (Neubert, Offenburg/Baden).

A descendant of this apparatus is the 8-dot shorthand braillewriter (see Figure 4). To the normal braille cell 2 dots have been added below. The

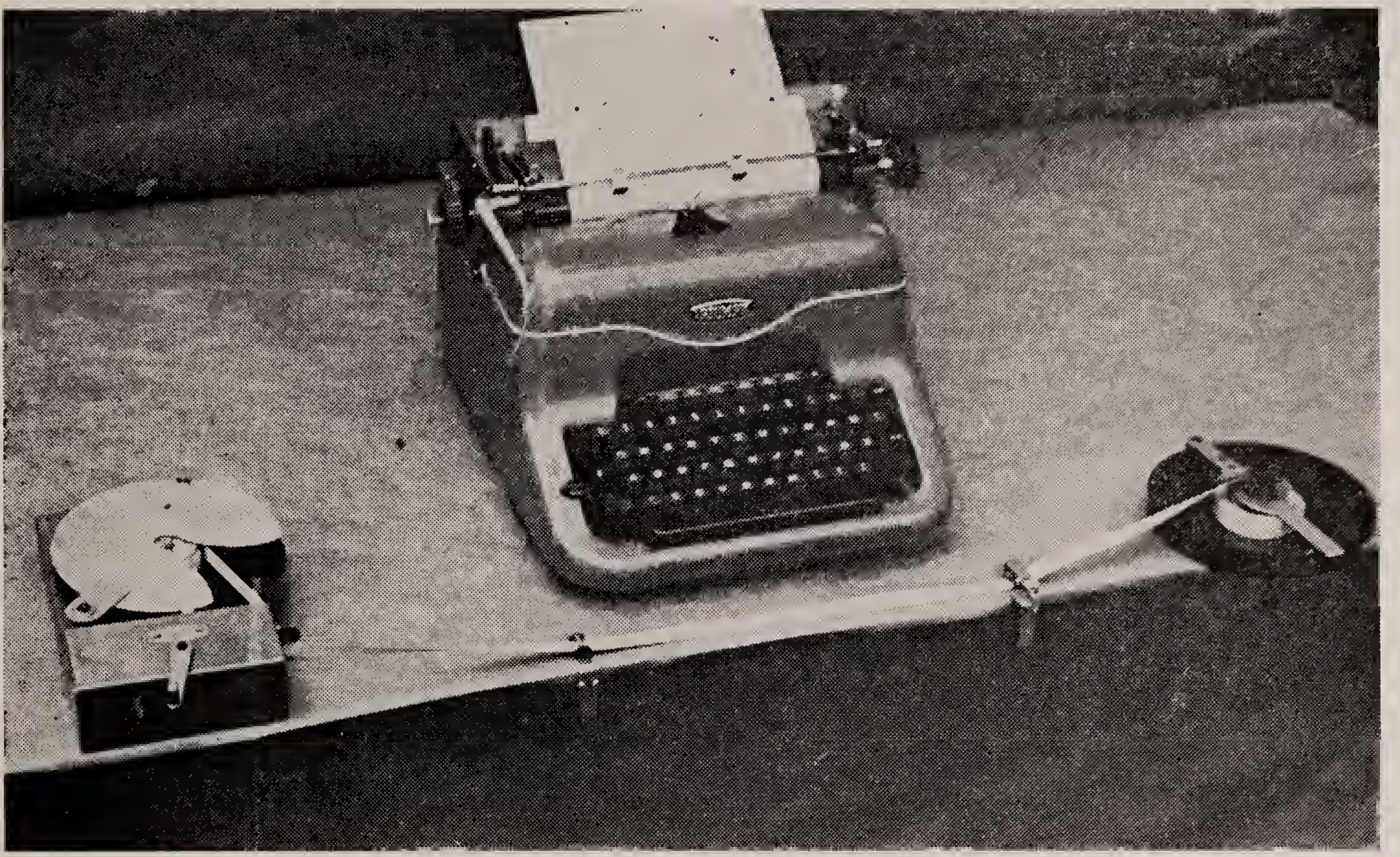

FIGURE 3 Clamp Tape Guide Setup for Transcribing onto Typewriter

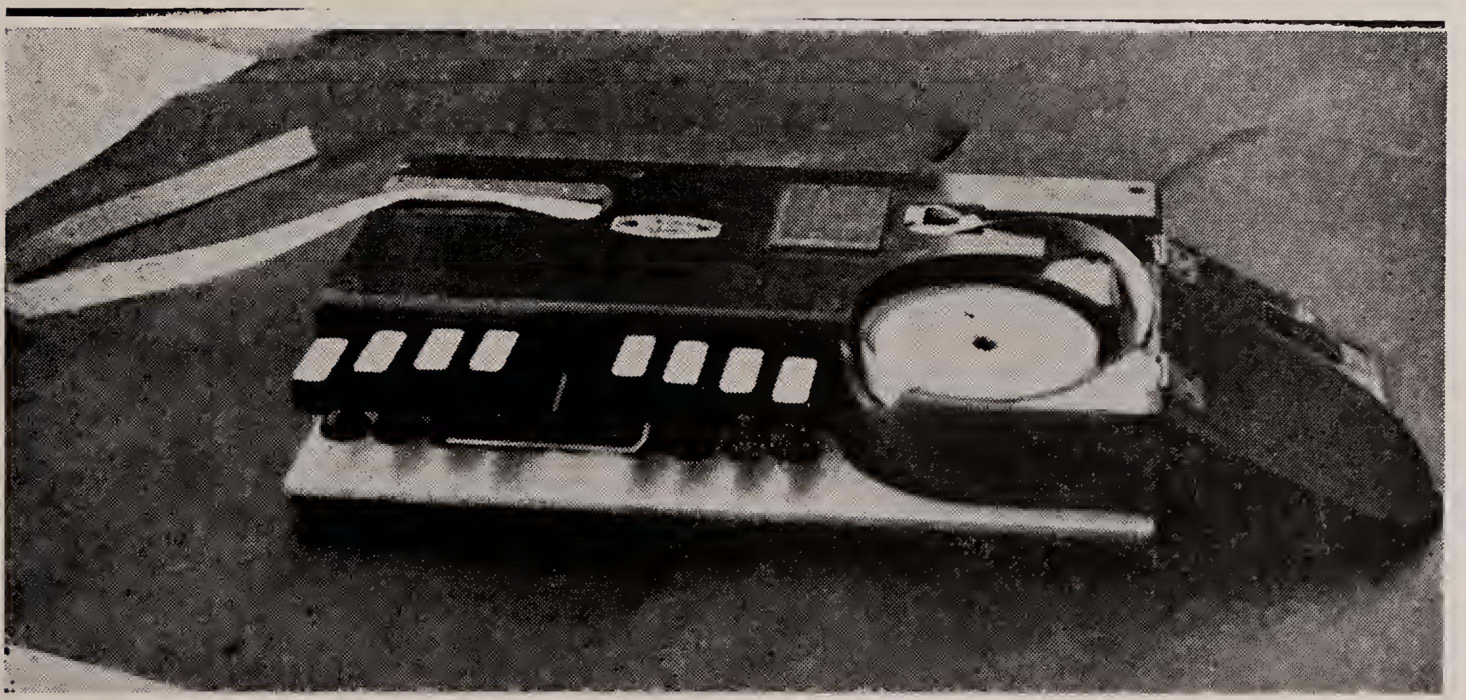

FIGURE 4 Marburg Eight-Dot Shorthand Typewriter

keys for these 2 dots are operated by the little fingers. Whereas 64 signs can be composed by 6 dots, 8 dots can be combined in 256 different ways. The 8-dot cell can therefore encode four times as much information as the normal braille cell. It is not easy, however, to assign meanings to this number of symbols. A new shorthand system has been worked out enabling good stenographers to increase their writing speed above 300 syllables per minute (320 syllables have been achieved in contests; 350 can be expected after some practice).

These two shorthand machines have opened the vocation of stenotypist to a great number of blind persons. Since ways have been found of adapting telephone exchanges, numerous blind switchboard operators have been employed. The keys to this vocation are two small devices: the first is a small solenoid which when energized pushes up a pin giving a tactile signal to the operator. This solenoid is inserted in place of the lamps which indicate over which line a call is coming. The replacement of the lamps by these solenoids enables skillful blind persons to operate even large boards. With the increasing use of long-distance dialing, an operator must have the possibility of checking fees. The checking system is as follows: The

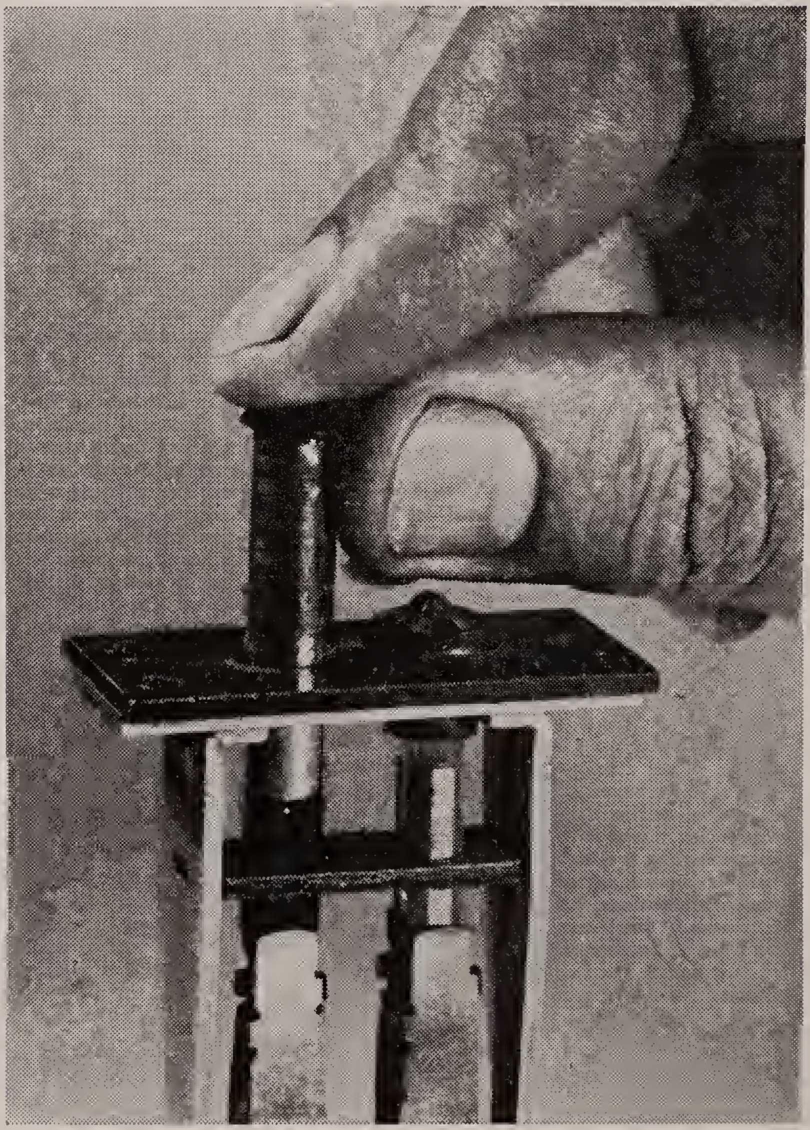

FIGURE 5 Tactile Signal Solenoid

lines are charged with short pulses at intervals whose length depends on the distance, and varies from 90 to about 6 seconds. These pulses are counted electromechanically and, when multiplied by a certain amount of money, give the charges for the call. The exchanges are provided with counters which must be adapted for a blind operator by marking with braille figures. Figure 5 illustrates the tactile signal solenoid made by Siemens and Halske, Figure 6 the complete telephone exchange, and Figure 7 shows a telephonist at her work.

Until recently teletyping was impossible for blind persons. The difficulty lies neither in dialing nor in writing but in reading the reply of the station called. This reply is important since it performs a control telling the operator whether or not he has dialed correctly. Two devices have been

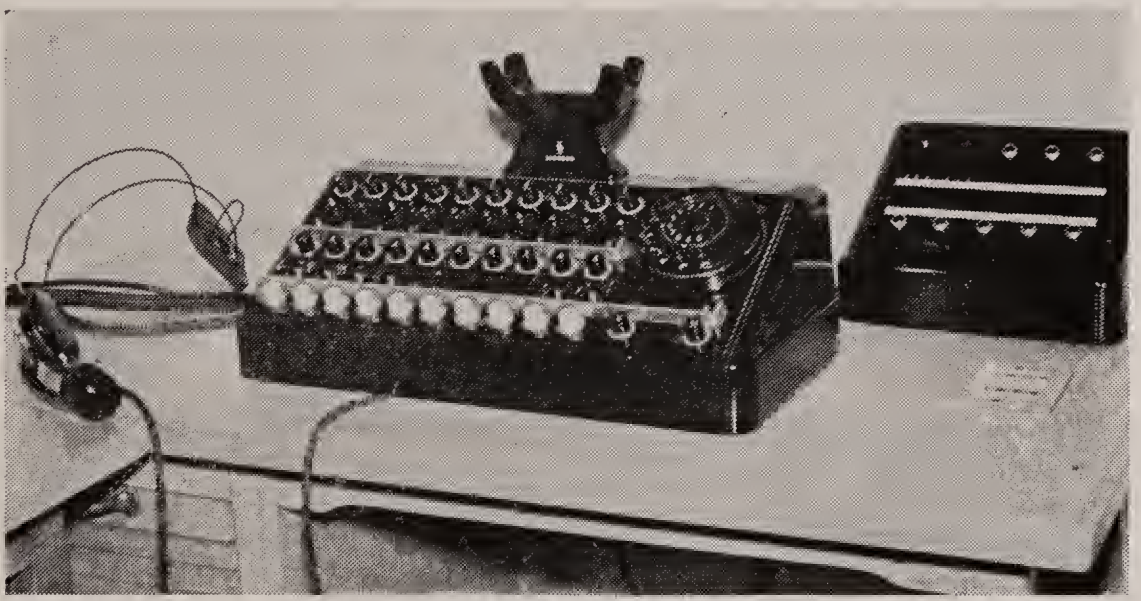

FIGURE 6 Telephone Exchange

FIGURE 7 The Blind Telephonist at Work

developed which solve this problem. The first, designed by a young physicist, translates the five-pulse code of the teletype system into the six-dot braille code and embosses it on a paper tape. Figures 8, 9, and 10 show this apparatus which consists of a translating and a writing unit. The former must be joined to a teletypewriter and contains only electronic components.

The second device is a normal tape puncher with a slightly modified punching unit. Whereas normally up to five holes are punched across the width of the tape, providing the 32 possible signs of the code, with this device the dots are embossed. The first device mentioned is a complex apparatus, but prints braille symbols with which the operator is familiar. With the second device he must learn a new code, but at least it is a commercially available device. Both devices are now being tested.

It ought to be mentioned that the electromechanical tape printer of the first device offers possibilities as an electrical shorthand typewriter with the advantages of an increase in writing speed with less manual energy.

Digital calculators have seldom been used by blind persons in the past, but various types of mechanical and electromechanical computers have now been modified. These are normal calculating machines bearing or generating braille figures in their counting units and having suitably marked keys. A

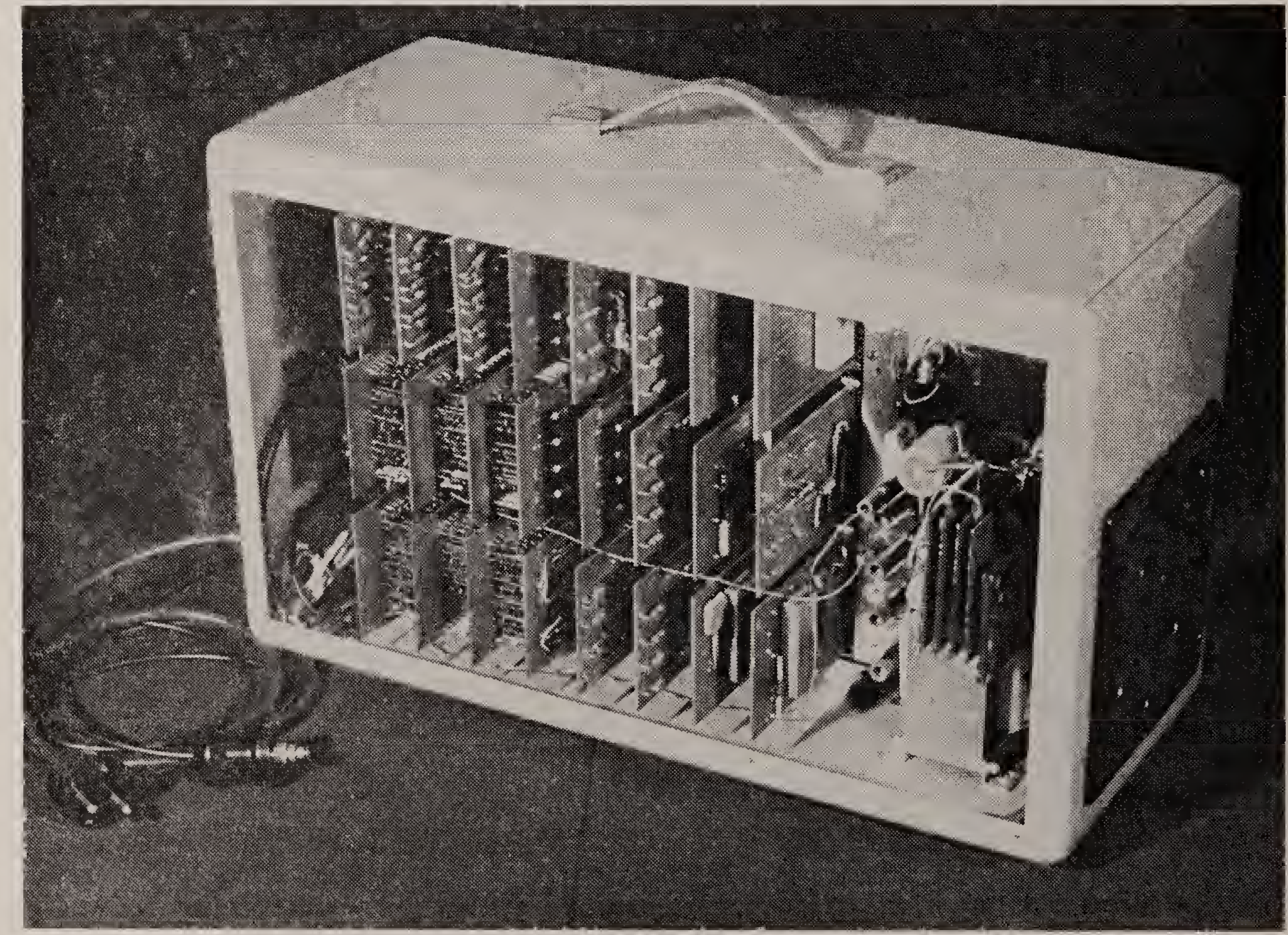

FIGURE 8 Electronic Decoding and Control Device for Teletyping

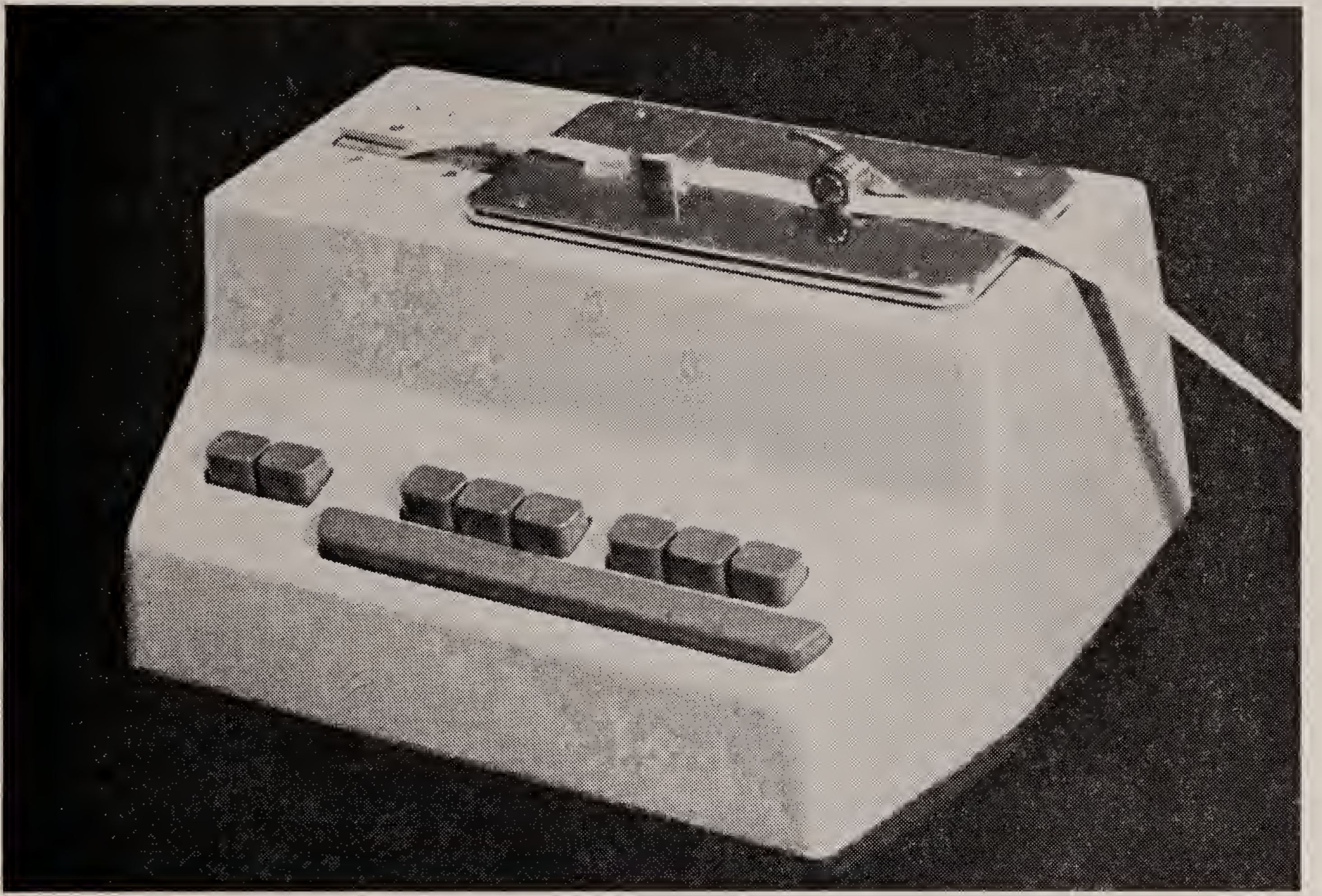

FIGURE 9 Electric Shorthand Machine for Teletyping

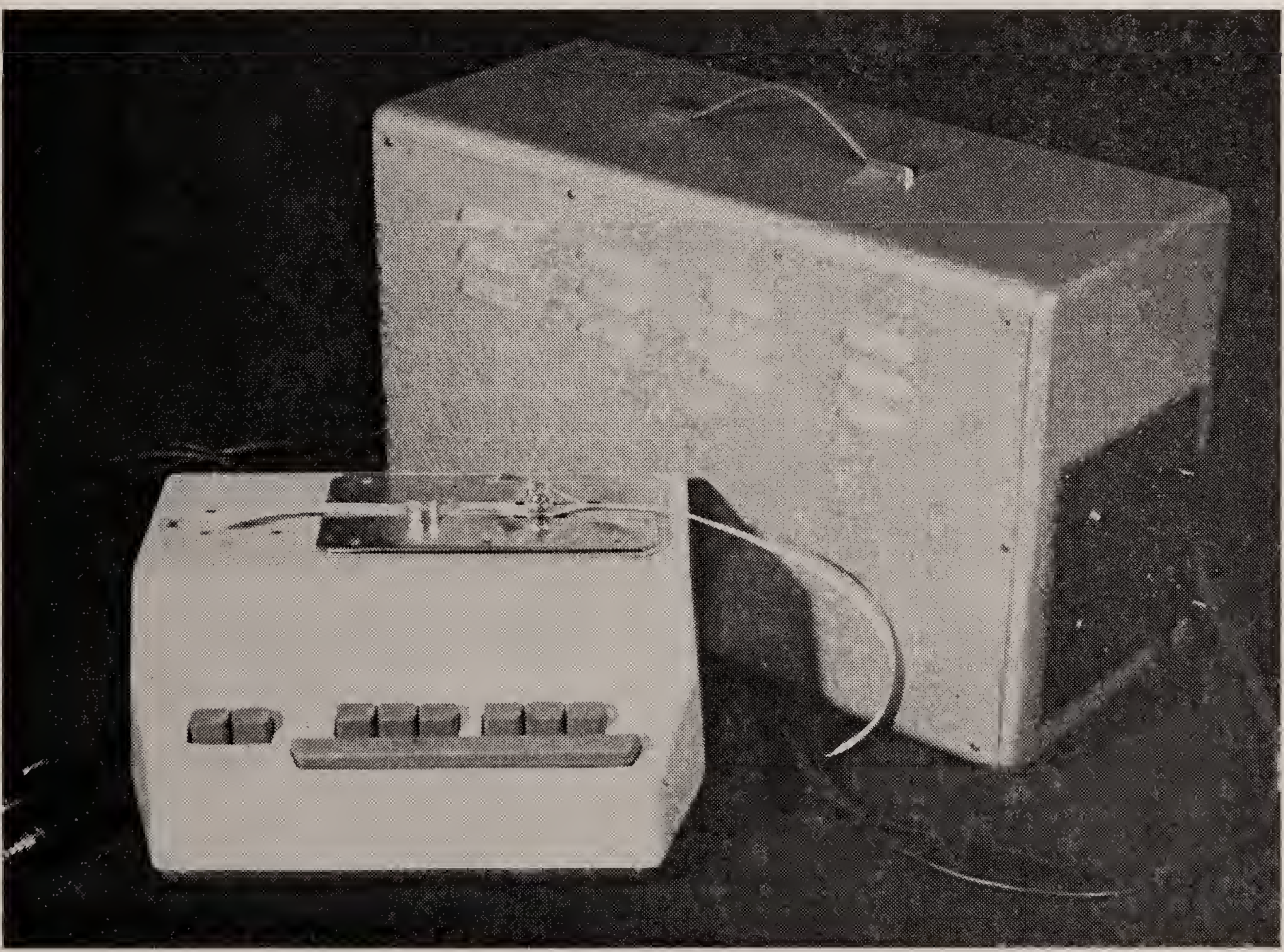

FIGURE 10 Teleprinter Device Assembled

Swedish firm produces a relatively simple computer for manual operation only. A German manufacturer offers various types of semi-automatic and fully automatic electromechanical computers of the kind shown in Figure 11.

The Marburg-Wien drawing method is remarkable both for its simplicity and its superiority to other methods. It was developed more than 30 years ago. Originally wax tablets were used instead of paper. A flat square metal pan held a layer of the specially composed tough wax. The lines were engraved on the smooth surface by a sharp steel pencil and properly shaped compasses. If the drawing was expendable the wax was melted by a gas flame or in an oven. After the war, however, the wax tablets were replaced by sheets of pressboard (a thick and very hard paper). The drawing procedure and the instruments (save for the pencils and compasses) are now standard equipment. The pressboard sheet is fastened on an ordinary drawing board, and the T-square, the triangle, and the curve template guide the steel pencil. A goniometer completes the set of tools.

Every kind of geometrical and technical drawing can be made in this

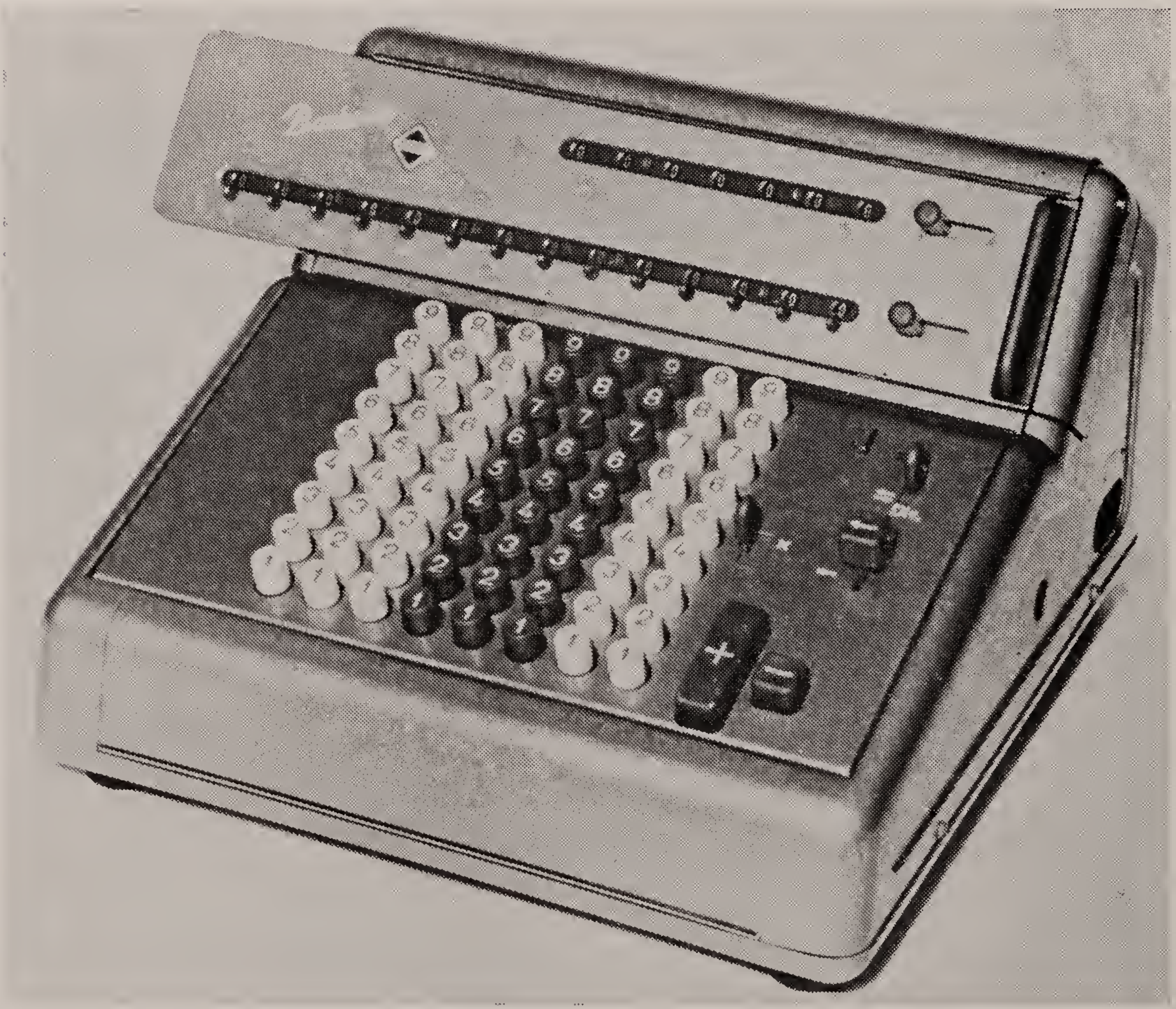

FIGURE 11 Electromechanical Computer Suitable for Adaptation for Use by the Blind

way. Steel pencils and compasses cut narrow furrows in the wax or pressboard. The edges of these furrows are tangible as well as visible. Figure 12 shows the set of tools.

Some other devices deserve to be mentioned. They are not vocational aids like those described above, but they can be very helpful to blind persons in various situations.

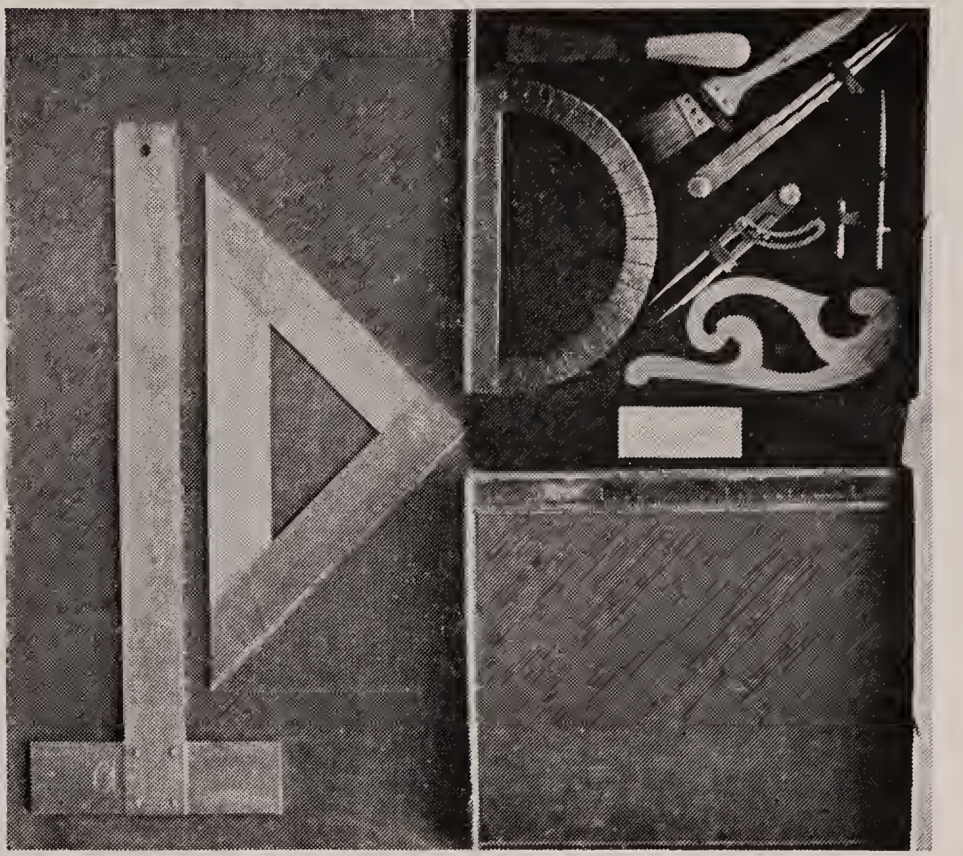

FIGURE 12 Tool Set for Making Technical and Mathematical Drawings

The difficulty of duplicating braille texts without printing machines has been solved by a development of the Blindenstudienanstalt (see Figure 13). Into a grid of rectangular cells, each of which will contain a letter, three rectangular pieces of metal are set, each bearing one dot, two dots or no dots at all. Cell after cell must be filled. A sheet of paper is then laid over the type, a matrix with six indentations for each cell is placed on the paper, and the braille is embossed. One sheet is then taken out and replaced by the next.

This is a bit tedious for long texts but the duplicating is easy and the necessary machinery is much cheaper than that needed for braille printing.

The great difficulty that deaf-blind persons have in communicating with others is relieved by a small device shown in Figure 14. It can be used if the other person is familiar with the braille system. The apparatus is small enough to be carried in the pocket. It is furnished with six keys similar to those of the braillewriter. By pushing down the keys short pins are raised within a small area opposite the keyboard on the top of the case. These pins form the dots of the braille cell. The deaf-blind person puts a finger on this area while his partner "writes" what he has to say. Since a shorthand system may be used, and since it is usually not necessary to "write" whole words, communication can go rather quickly.

Calipers for use by the blind have not been available in the past since

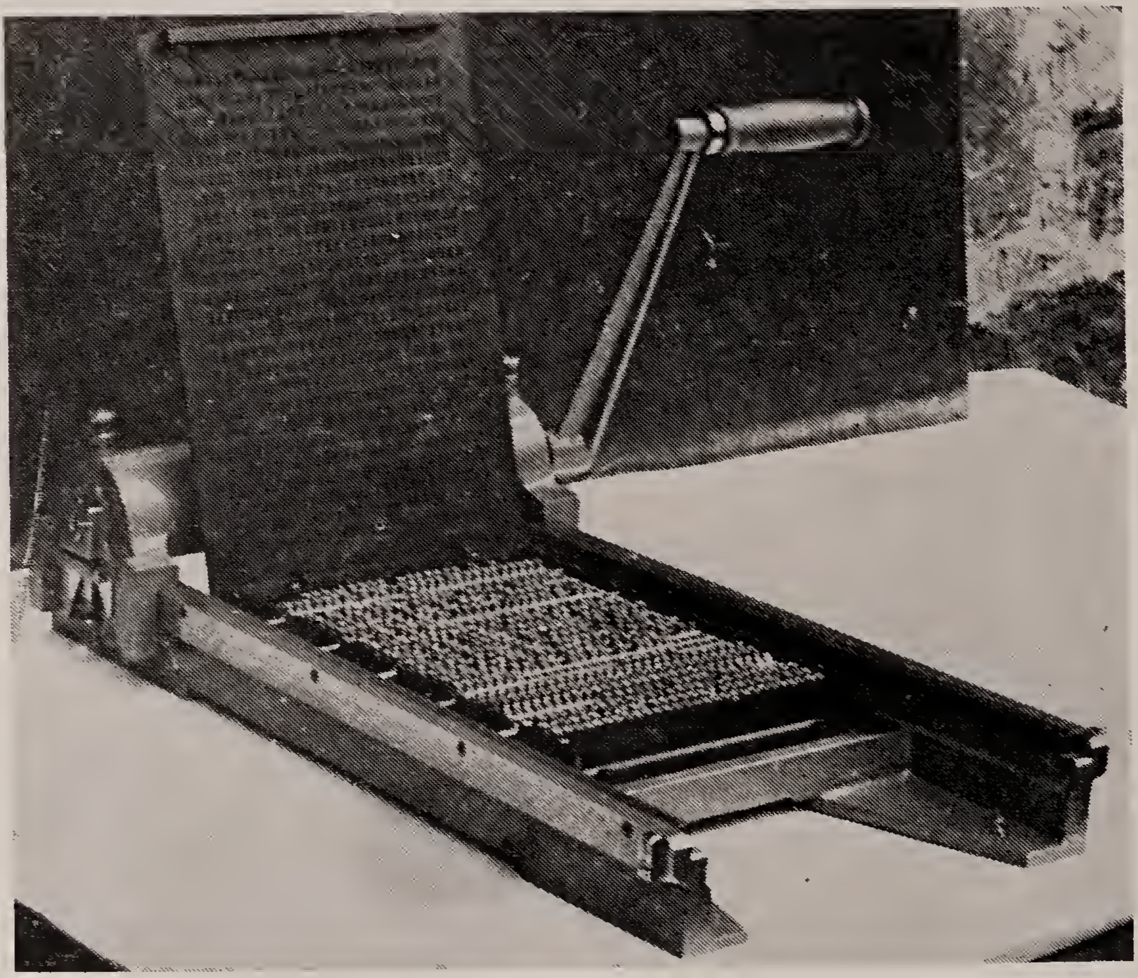

FIGURE 13 Marburg Braille Duplicator

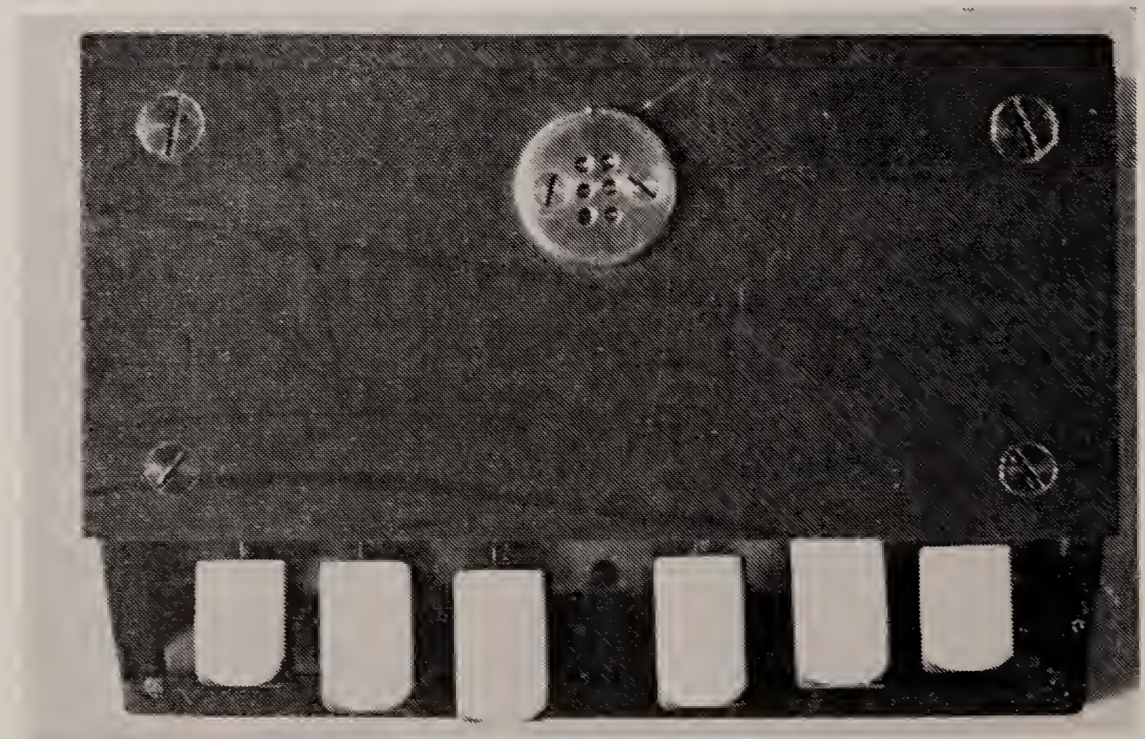

FIGURE 14 Marburg Deaf-blind Braille Communication Device

an adaptation is rather difficult. With the model shown in Figure 15 the adaptation was especially easy and successful. Since the scale is spread along the edge of a relatively large disk a vernier scale can be omitted. One turn of the screw represents 1 mm, so that thickness can be measured precisely to .01 mm. The device was originally intended for blind piano tuners but it works just as well in the workshop or as a control instrument in industrial work.

The last thing which I will mention is a technique for soldering by means of a carbon rod (see Figure 16). The free end of the carbon rod is sharpened. The other is connected with one terminal on the low voltage side of a transformer. The other terminal is connected with an alligator clip to a tinning wire. The point of the carbon and the solder are put on the joint to

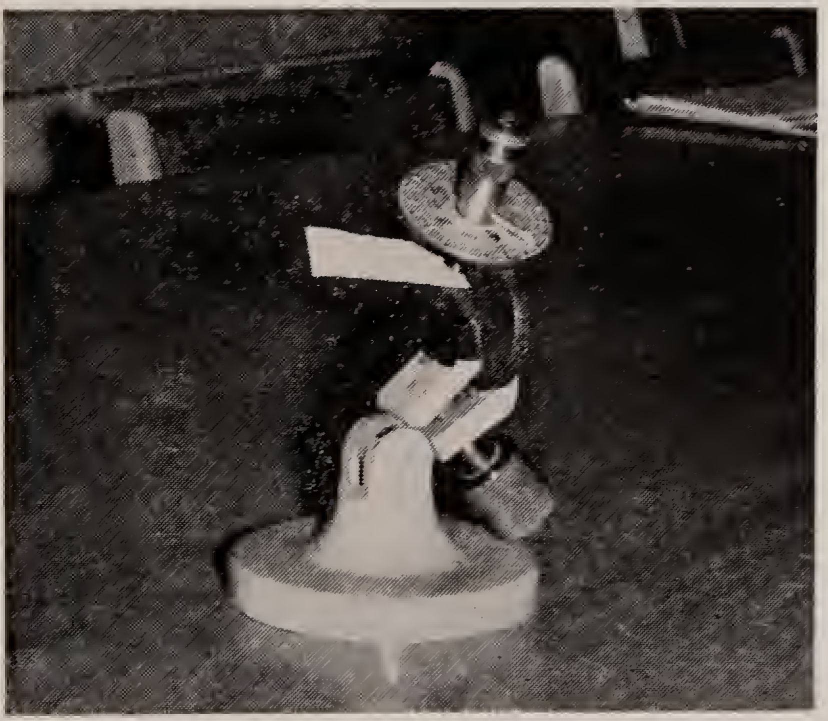

FIGURE 15 An Adapted Caliper for Use By the Blind

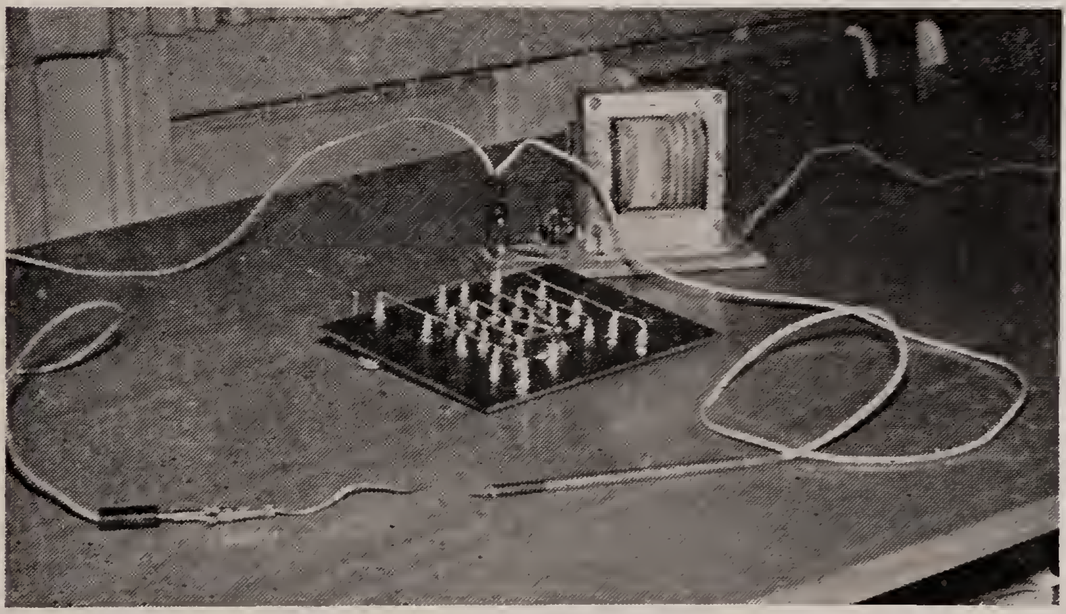

FIGURE 16 Soldering Device for Use By the Blind

be soldered and the transformer is switched on. At voltage of 5 to 10 volts a current of 20 to 40 amperes will flow. The carbon point becomes hot very quickly and heats the joint enough to melt the solder and join the metals. This method is probably the best general technique for blind operators (radio amateurs, et al.) since one is handling a cold tool which heats quickly and only when connected with the soldering joint.

All the devices described above (except the soldering tools) are distributed by the Blindenstudienanstalt/Marburg.

DEVELOPMENTS IN VOCATIONAL AIDS: NETHERLANDS

ROELF G. BOITEN
Technische Hogeschool, Delft, Netherlands

Before and shortly after World War II the various groups of handicapped persons in the Netherlands—the blind, the deaf, the victims of polio, the rheumatic, etc.—each had their own organization whose main purpose was to defend the rights of its members and to improve their social status. The oldest of these are the organizations for the blind. There are a number of them, and they are divided on matters of religious faith and social position.

Each organization established its own policy and behaved as if its members were the only ones who mattered. In this unfortunate situation, the blind were the first to realize that a combination of efforts would be more effective. They agreed to cooperate and provide centralized services for practical and immediate problems. Some years ago the organizations for the handicapped decided to unite in a single national organization, the Netherlands Union of Handicapped Persons (NCVG), governed by a board selected from among members of the various associated unions. For the first time the problems of all the handicapped could be viewed on an overall basis and problems common to all could be identified.

As separate organizations they had no funds for research and were scarcely aware that there existed such a thing as scientific research or a scientific approach to problems. A few years ago the NCVG, together with some other organizations and government agencies, established the Information Center for the Physically Handicapped (VLG), which represented all handicapped persons in the Netherlands. Now the problem was to give a meaning to this splendid voluntary organization. Again it was the blind who took the initiative. They asked me to advise them about the means and possibilities of scientific research. They presented me with a number of questions and problems, many of which I could answer from my own experience. It struck me that organizations for the handicapped lacked scientific help while in the universities and laboratories an abundance of knowledge was available. This indicated that a bridge between these institutions was lacking and I made it my personal goal to provide such a bridge, not an unlikely proposition for a professional mechanical engineer like myself.

Since there were no funds, everything was started on a voluntary basis. I obtained the cooperation of a number of Dutch professors, students, assistants, and laboratories, and we formed a group called the Working Party on Adaptation Instruments (WAI), of which I have the honor of being the chairman. The group started with a list of some 60 problems submitted by the various organizations. At the moment the WAI is the most aggressive part of the above-mentioned VLG. It has its own office and full time engineering and clerical staff. This staff coordinates the work being done in the various laboratories and universities. Many important people in the Netherlands volunteer their time and energy to these problems. I have estimated that if these services were compensated for at the current rates for consulting work it would amount to something on the order of $100,000 a year!

Since work is conducted for the benefit of all the handicapped, blind persons included, the efforts are concentrated and are not duplicated. I believe this centralization is unique in the field of work for the handicapped. With regard to the scientific aspects, you will understand from my background that my approach is from the cybernetic standpoint. Cybernetics is the science which investigates and describes the similarities between machines and living organisms and the problems arising when machines and men have to cooperate.

Let us analyze a simple human behavior pattern. One walks along the street and suddenly an obstacles makes passage in the original course impossible. What happens? We see the obstacle, hear it drop, stumble over it, touch it by hand or cane, or perceive it in some other way; at any rate a message concerning the obstacle is transferred to the brain. Our contact with the world is exclusively by means of the sense organs and without these we could not "live" in the normal sense of the word. The brain can be considered as the command center of our body, and a great many reports about our situation with respect to the environment are continuously coming in via the nervous system. In the brain a kind of data reduction takes place in which the information is compared with the desired behavior patterns, etc., and conclusions and decisions are formulated to prevent undesired consequences in our relationship to the environment. From the brain, commands are formulated and transferred to muscles which perform corrective movements. The muscles themselves send back reports concerning the way the commands are obeyed, the position and velocity of moving body parts, and so on. This information is continually checked against the information received from our sense organs and, if necessary, further corrections or modifications of the command signals are made. Thus we are able to circumvent the obstacle, regaining our balance if we have stumbled, etc.

With a disabled person something is missing. It may be one or more senses, or a limb, or there may be a defect in the neuromuscular system. The remittance of information as to the effect of the command signals and the comparison of the actual situation with the desired situation is called feedback. This mechanism is the working principle of all living systems and of all engineering systems. With blindness, the information channels related to vision are not available. In the human these channels provide the largest part of the information on which decisions are based. A first solution seems to be to provide the brain with the information lacking via other available sensory channels, and most devices designed up to now are based on this philosophy. Now consider the eyes as a highway carrying most of the information traffic and the other senses as secondary routes. Chances are that when all the traffic is passed over these secondary routes either some jamming will occur in the other sense organs or affiliated nerves, or the data reduction capacity of the brain itself will be reduced.

Unfortunately very little is known about these things and part of the research now going on is intended to obtain more information about the behavior of our information channels and brains. From an engineering point of view it is feasible to transform information about the distance, dimensions, and structure of objects into sounds of appropriate level and frequency. A test subject told me he felt as if he were in a bird cage when using such an instrument. It requires considerable data reduction in the brain to abstract the required information from these sounds. Such a device cannot restore vision and in addition deprives the person of part of his normal hearing facility. Human beings are the most highly specialized living creatures, as is evidenced by their central nervous system. The nervous system of lower animals reveals little possibility for intellectual activity but is, therefore, from a mechanical point of view less susceptible to damage.

Our approach to devices is to provide them with a kind of electronic brain which is able to do some data reduction so that partly formulated conclusions may be transferred to the brain. This decreases the need for information channels to the brain and would prevent the above-mentioned jamming. For example, an acoustic orientation device might incorporate a circuit which could recognize sound patterns, and conclude that this obstacle is a light post and that obstacle a wall. A device that does some data reduction and formulates conclusions is sometimes called an automaton. A number of such devices presently exist; a prime example is the autopilot in aircraft, which relieves the pilot of part of his work.

How much exchange of information there should be between the automaton and the operator's brain is the basic question. Too little information makes it impossible for the human to detect in time dangerous situations and formulate the proper commands. Too much information may overload the perceptive capacities and data reduction facilities of the brain, causing malfunction and inappropriate conclusions and commands.

In our civilization the influence of automation is rapidly increasing. More and more of the task of decision making is transferred from men to machines. Since we live in a society increasingly dependent on machines, the knowledge of the relation between human beings and automatons is of utmost importance. Study of this problem is hampered by the fact that man has an abundance of information channels, so that it is difficult to decide which of the available channels should be used and to what extent. Persons with sensory disabilities have fewer available channels, and thus are ideally suited as test subjects in these investigations. In this way the disabled can perform an important function in helping to increase our knowledge of human behavior, knowledge which is vitally needed if we wish to keep our changing automated world as a place worth living in. At the same time this knowledge will lead to technical devices which will improve the conditions of the blind and of other disabled persons.

Present research in Holland is not confined to problems of the blind, but covers a far wider field—for example, the study of automated moving prostheses for amputees.

We have short-range goals and long-range goals. Our long-range goals are scientifically based attempts to obtain the information and knowledge about human behavior which might enable us to construct better aids for the handicapped. On the other hand, we don't want the blind to wait until we have solved this very difficult problem. Therefore we also devote our efforts to solving problems of immediate concern to the blind. Much of this work is done on an individual basis under the supervision of a blind person. We try to devise ways and means with which he can perform his original job or a similar one. Thus the abilities which a person has or had before blindness occurred are utilized. As for the congenitally blind there is the advantage that we can work on the professional level. I dislike the idea that blind or disabled persons should be pitied and led into some kind of social security. They should be fully responsible members of our society. Only if they are quite incapable of this responsibility should they receive suitable assistance.

We have done some work on the improvement of tape recorders for talking books, correspondence, etc. The modern tape recorder is to a blind person what a notebook and pencil are to a sighted person. Unfortunately the normal tape recorder is designed for sighted people and many blind people have difficulty in using it. After some investigation we found several things on tape recorders which might be changed. This has given rise to a small research program now carried on by a few of my students.

One of the problems with the tape recorder is adjusting the modulation level, which determines to a great extent the properties of the recording. You are probably aware that in the commercial tape recorder there is some kind of indication of modulation level, usually a "magic eye." This magic eye is of no use to a blind person. Research has been carried out on an audible system to indicate the modulation level. Two devices are in the prototype stage. One is designed to be built into the apparatus, and this is only of importance for new or specially built apparatus; the other is a photocell device which is over the magic eye and which transforms the intensity of its light into an acoustic signal. This can be adjusted for use on any known commercial tape recorder. There are a few blind students working with it and they have had very satisfactory results.

A second problem with tapes is finding a certain place in the tape rapidly. It is difficult, for example, to find a particular chapter and verse in a recording of the Bible unless you have an intimate knowledge of the book. After testing a number of possibilities we have decided it would be best to provide this information aurally from the tape itself. This can be done by superimposing spoken information regarding the contents of a track in such a way that this information is only reproduced during Fast Forward/ Fast Reverse. It requires only a slight modification of the recorder. Furthermore there is little or no deterioration in the quality of the sound.

A third problem in connection with the use of tapes is that of splicing. With available splicing apparatus it is difficult even for a sighted person. For a blind person it is even more difficult to get the tape spliced in such a way that you have a perfect joint without jumps in sound. One of my students undertook to design a tape splicer especially for use by the blind. This instrument makes perfect repairs and can be handled easily by any blind person. It does not use sharp knives with which they may cut themselves and there are no loose parts to be lost. The price is about $12. Here again the largest market is found among the sighted rather than the blind. (See Figure 1.)

Another device we made was a syringe for blinded and partially sighted persons. Strangely enough, this request came from a group of medical doctors who suffered from eye impairments and were not sure they could see clearly what they were administering to their patients, and from two professional nurses who had difficulty in administering to their diabetic patients the required injections of insulin. The syringe we have developed is medically approved and very accurate. In fact it is more accurate than the normal syringe which is filled by locating divisions on the glass syringe. Many sighted people are buying the syringe because loading by tactual sense has proven more reliable even for sighted people. The price is about $15. (See Figure 2.)

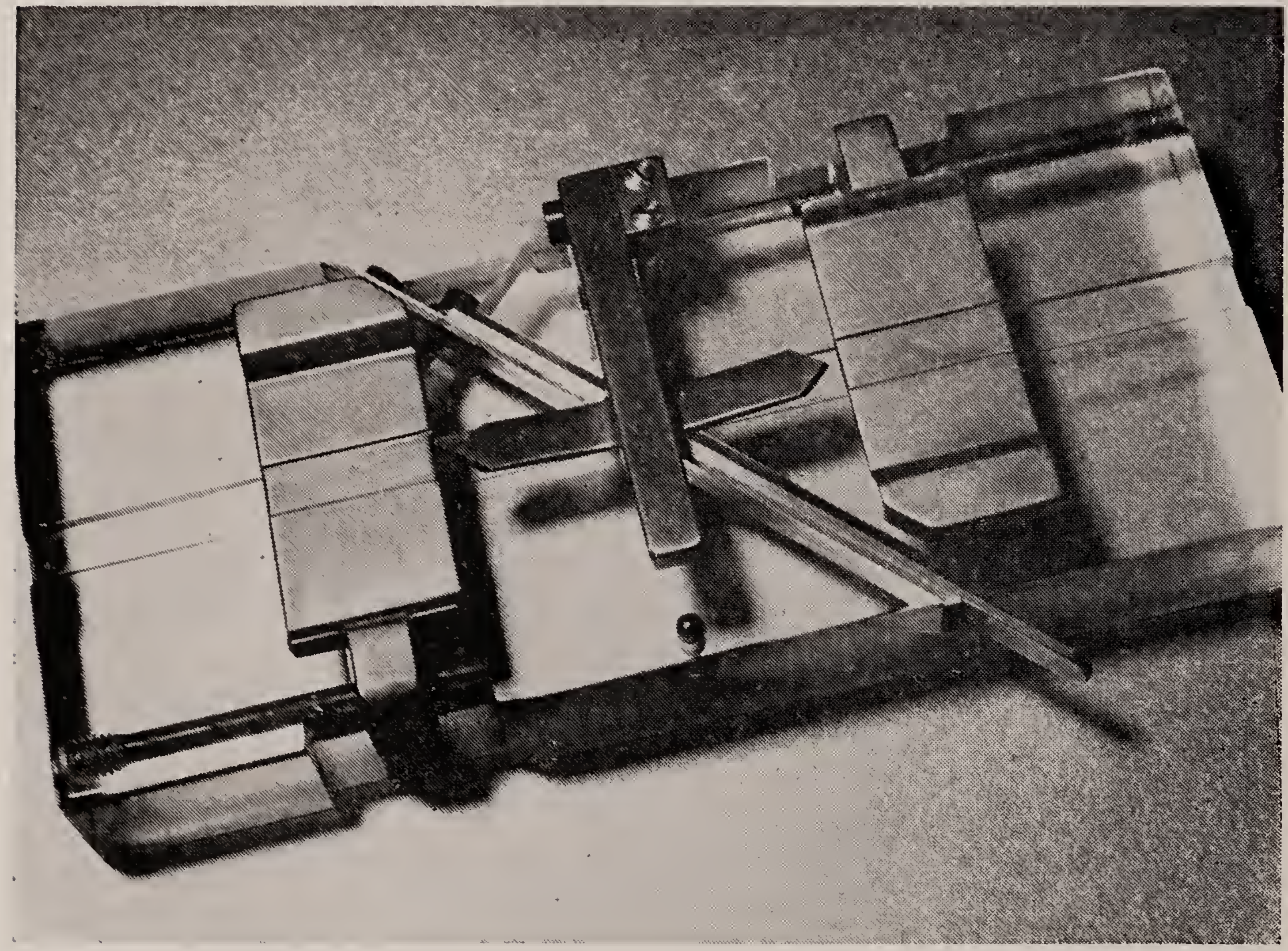

FIGURE 1 Tape Splicer for Magnetic Recording Tape

Another group of students is working on the problems of high school and university students. We believe it is better for blind students to attend a normal school rather than a school for the blind, especially if they intend to go to college. The blind have no appreciable difficulties in high school. They have battery-fed portable wire recorders and they have some help with their examinations. But there are some subjects which give them difficulties; for example, geometry, chemistry, and physics. In physics, with slight modifications of the existing equipment, nearly all physical phenomena can be presented realistically to the blind person.

In geometry, however, things are more difficult. For many blind persons it is difficult to get an idea of three-dimensional structures and their inherent relations. At the moment we are conducting tests with simple aids consisting of flexible joints and wooden sticks which can be broken to any desired length. It works nicely, and all figures studied in high school geometry can be constructed.

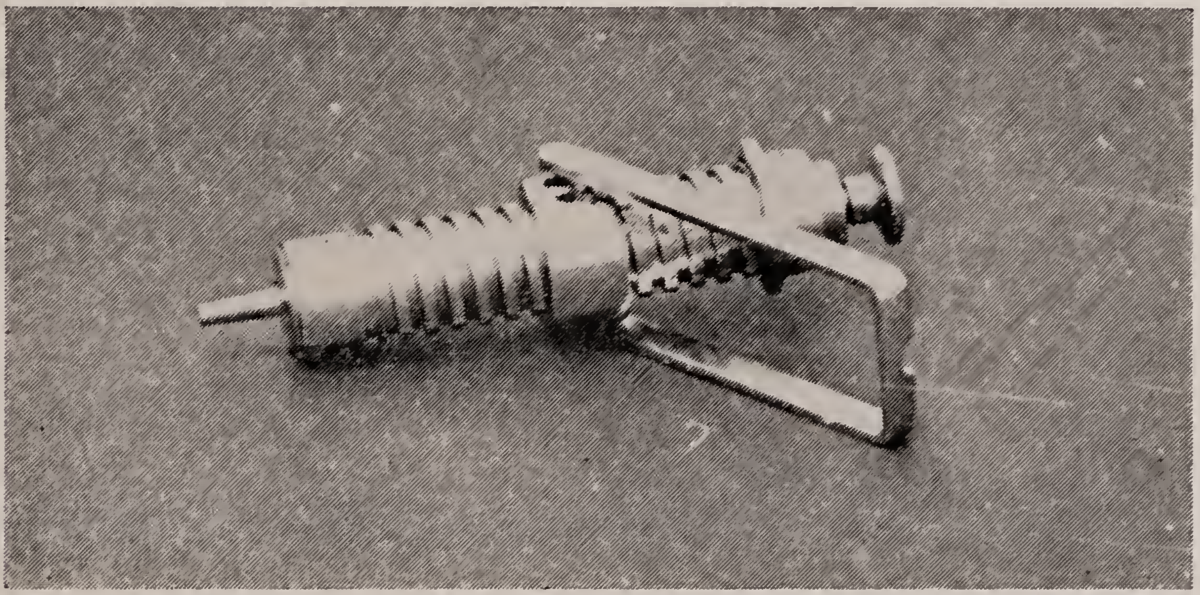

FIGURE 2 Hypodermic Syringe with Tactile Markings

A group of students at one of our universities is making some three-dimensional models for chemical studies. These models will provide the student with an appreciation of valence and other properties of various atoms, and enable him to construct atoms and molecules from their simpler parts. It is not yet finished, but I believe we will soon have some prototypes to work with.

Another problem in chemistry is detecting color changes associated with the chemical reactions. We now have a prototype of an apparatus in which color changes are translated into an audible signal. The British instrument designed for the same purpose is more elaborate and definitely superior to ours. On the other hand, ours is relatively cheap and works quite well.

Then there is the problem of making graphs, which may be used in combination with talking books, or for the evaluation of measurements, etc. A few chemistry students at the University of Utrecht have been using a paper impregnated with certain chemicals. Lines are made with a fountain pen containing another chemical, and when the two chemicals come in contact, an embossed line appears in a few seconds. There are still some minor difficulties, but it is a very promising solution.

We have also developed a device which transforms oscilloscope traces into a tactile form, a mass counter for physics students, etc.

We have worked on several household devices. I will not mention all the devices which we have made. I have two students who work on household problems. One of the most charming things they made was a teapot which automatically pours a measured cup of tea and then stops. After returning it to a horizontal position, it is ready to pour a second cup, and so on. We have made a film of a sighted person serving tea and a blind woman serving tea, and there is no observable difference. This teapot, unimportant as it might seem, may go a long way in restoring the self-respect of blind housewives.

We have also developed a simple light detector. It is pocket sized, transistorized, and powered solely by a photocell. It gives an audible signal when turned toward the light. It can be used to tell if a light bulb is turned on or off, to locate windows, etc.

Another problem being worked on at various places in Holland is the braillewriter operated from perforated tape. We have difficulty in our country finding persons who can use the normal braillewriter to make braille copies of scientific literature, etc. On the other hand, we have many volunteers who can type and are willing to spend time preparing books for the blind. Our solution is to let them type on a normal typewriter with a tape perforator attached. Then an editor can read the typewritten pages, detect errors, and correct the tape. This tape is processed in an IBM computer which has as its output a tape programmed in braille. This tape is then fed to an electric braillewriter. We are designing a braillewriter which will print a line at a time with a speed of 10 to 15 lines/second. In that way, we will be able to reproduce a complete braille book in a few hours time. All instructions for the format, such as end-of-line, end-of-page, etc., are included on the tape.

Another problem of great interest is the mobility of blind persons. I am quite certain that for the next five or ten years there will be no feasible solution for this problem. On the other hand, we didn't want blind people to wait that long, and so we have proposed (and have actually under construction in some places) a guidance system in public buildings such as railway stations and post offices. It consists of buried wires fed by an audio frequency. The blind person wears an earpiece which is tuned to that frequency. It is something like using a mine detector; he hears a strong signal when he is on course, and if he strays to the right or to the left, the sound becomes weaker but is still available. Thus if he encounters other persons, he can detour to avoid them, and then return to his path. We did some tests using several channels which would be useful, for example, in a railway station to locate a particular platform. The same thing could be done in a post office. We expect that this relatively inexpensive system will enable many blind persons to be more independent and to find their way more easily.

Another question put forward by people in various professions was the need for a small portable braillewriter that would be inconspicuous and could be placed on the lap. We have a prototype which is very small and uses paper rolls about three inches wide. It writes a few words on each line and thus is suitable for short notes. The machine is about five inches high, four inches wide, and one and one-half inches thick. It fits easily into a trouser pocket. From the mechanical standpoint it is a nice piece of engineering, and the price will be relatively low.

The last item I will mention is something we designed for the partially sighted: a special reading desk which can be folded in a small package. It is used in conjunction with high magnification and enables the partially sighted to read books and papers without too much difficulty. The desk is priced around $30 and is now being built in relatively large quantities.

PROFESSIONAL OPPORTUNITIES FOR THE BLIND

NORMAN M. YODER
Office for the Blind, Harrisburg, Pennsylvania

THE SCOPE OF THE PROBLEM

Those of us who have been concerned with the placement of blind persons in gainful employment over the past two decades have had a tendency to overlook the opportunities existing in the many professions, simply because there was little, if any, "know-how" among the agencies for the blind. Thus, those blind persons who entered professional employment and achieved some degree of success did it in spite of, rather than with the assistance of, public or private agencies. There has been and still is a general feeling that to sponsor a blind student through undergraduate and possibly graduate work is a costly investment; particularly if the result, namely employment, is uncertain.

We knew that, over the years, many persons had gone on with professional training and only after long years of heartbreak, hardship, and disillusionment, did they ever find an opportunity to enter the profession and achieve any degree of success. We also believed that during the past two decades many agencies which underwrote the cost of professional training did so because they did not know what to do with the applicant and a four-, six-, or eight-year college stay was a device to avoid the problem at hand.

Why should these uncertainties exist for a blind person? It was our general impression that agencies and staff did not know very much about an organized approach to placement in professional occupations. Techniques were uncertain. Knowledge about blind people in the professions was lacking. Identification of the problems and possible solutions concerning continuance in a professional occupation were unknown. The kinds of technical equipment, service, and entrance level requirements were only suspicions not facts. Thus, in a period when professional training, specialization, and college degrees had become important, work for the blind did not keep pace.

For some years we have been gathering these impressions on a limited basis in order to carry out some experimentation regarding the problems facing blind persons in professional occupations. However, there seemed to be sufficient evidence at hand to propose to the Office of Vocational Rehabilitation (OVR), Department of Health, Education, and Welfare, Washington, D. C. that the entire area might lend itself to a research project. With the approval of Mary E. Switzer, the Director of the Office of Vocational Rehabilitation, and the encouragement of Louis H. Rives, Jr., Chief of Services for the Blind, OVR, the grant was made to our agency provided we could present a design which would make a contribution to the field of services for the blind.

THE RESEARCH PLAN

In January of 1960 we invited a small group of nationally known figures in work for the blind to discuss the research possibilities, to evaluate the problem, and to assist in designing a project which might be acceptable for a national study. After three and a half days of intensive deliberation the following program was submitted to the Federal Office.

This planning group confirmed in detail the impression that there was little concrete knowledge about the problems and solutions, the types of blind individuals who were in professional occupations, the kinds of professional occupations suitable for the blind, and most important, the techniques which exist (or which might be developed) to increase the number of blind persons finding employment in professional occupations.

We presented the following plan for consideration:

1. That we secure, through the cooperation of public and private agencies and other groups, a bank of names of blind and visually impaired persons in professional areas of employment.
2. That rather than send a questionnaire which at best lends itself to individual interpretation, we design an interview guide and subsequently train an interviewing team to meet with these persons on an individual basis and tape record each interview.
3. That we evaluate this data and translate it to key punch cards for statistical purposes.
4. That having evaluated, sorted, and analyzed the information we produce a training course for agency personnel based on the research.
5. That we refine the research data and publish a monograph with the title: *The Techniques of Placing Blind and Visually Handicapped Persons in Professional Occupations.*

The OVR found this research design acceptable and made the grant for the initial phases. We ultimately developed a bank of 800 names of blind persons in various professional occupations. We wrote to them, explained the objectives of the research, and asked whether they would be willing to cooperate. We had hoped for a reasonable response; it was overwhelming. Better than 97 percent indicated their willingness to help.

Our criteria for the interview were simple:

1. Was the person legally blind within the generally accepted definition of 20/200 or less with best correction?
2. Did the individual achieve the same economic status and position in the professional occupation as his sighted brothers, having been in that profession for an equivalent period of time?
3. Was the individual actually functioning on the job or was he there in name only with sighted assistance really furnishing a buffer situation?

The interview team consisted of three partially sighted individuals and one sighted individual, each equipped with a tape recorder. They crisscrossed the country interviewing blind persons on the job, in their homes, or wherever it was possible to meet them. The interviews ranged from 40 minutes to two hours in length. The interviewer was instructed to use our material as a guide only, and when interesting points were raised during the course of the interview, to pursue them to whatever depth seemed appropriate. Our interview team had five days of intensive training under Mary K. Bauman of the Personnel Research Center of Philadelphia.

We had hoped that in the three to three and one-half months allocated for the interview activity we might contact between 200 and 275 of the persons signifying an interest in the study. Because of the enthusiasm of the interview team itself, we were able to interview more than 500 of these persons in the allotted time, with the result that we were able to investigate thoroughly 15 distinct professional occupations.

In May and June of 1961 we offered the first course of two week's duration in the techniques of placing blind and visually handicapped persons in professional occupations at Reading, Pennsylvania. Seventeen staff people from the various state agencies enrolled. We used edited sections of the taped interviews, presented lectures, used blind persons in the professional occupations covered as resource and consultant personnel, and included several areas for staff training. It was apparent to us that a breakdown in placing more blind persons in professional occupations occurred because little or no knowledge was available in these areas.

Because of a number of requests received from other state and private agencies a similar course will be offered in the fall of this year. The site and dates have as yet not been selected.

The third and final phase of the research project is now in its concluding stages: the production of the results in final form for distribution.

The Division for the Blind of the Library of Congress, Washington, D. C., has had the results of the study recorded on three reels of magnetic tape. The American Printing House for the Blind completed the brailling of the volume and its recording on talking book records. The inkprint version is available for national and international distribution now.

WHAT DID WE LEARN?

Having completed the research it may well be asked, "What did we learn?" If the size of the volume is any indication we learned a great deal. We prefer to be judged by its contents. The interviews and the analysis of the materials gathered gave us some guidelines concerning the selection of candidates for professional training which should be reviewed.

Too frequently we become enchanted with the academic record of a blind person at the high school level, feeling that if his grades are adequate or high he is automatically a candidate for college. Nothing could be farther from the truth than this assumption for there are many other factors involved. For example: were the grades actually earned or given him by a teacher because he was blind? What is the academic standing of the school itself, be it a private school for the blind or a public school? How much help did the blind student require to achieve his academic standing? In sum, then, academic standing alone is not sufficient.

It is well to consider the extracurricular activities of the individual. Was he accepted in clubs, organizations, etc. at the high school level? If he was accepted, did he participate? Here again, it is necessary to evaluate the status of the blind person in relationship to his surroundings and his fellow students.

The third factor is basic and must be considered prior to enrollment at the college level. This is the individual's ability to manage his personal life and affairs. Factors that were considered included:

1. Does the student display independence in mobility when the occasion requires? That is, the ability of the blind or visually impaired person to get about, and not to depend upon a sighted guide at all times.
2. Is he socially conscious in dress, grooming, makeup, and other factors which help construct a total person?

3. Does he have the necessary skills in communication such as typing, braille, or other systems with which notes can be taken and examinations written?
4. Has he acquired acceptable social skills including good table manners, ability in self-expression, group participation in activities and other factors?

These are at least a few of the areas which we deemed vital prior to enrollment for professional training. Certainly the research has borne us out.

We believe that an applicant for professional training must have one other accomplishment; namely, adaptability—adaptability in attitude, adaptability in changing circumstances, adaptability to surroundings and to people. While he may enter college with preconceived ideas regarding his professional ambitions and desires, it is well for him and for the sponsoring agency to remain sufficiently flexible to accommodate changing points of view as the blind person gains experience at the college level.

In the preceding statements we have laid down some basic ground rules for the blind person. The sponsoring agencies are not without their responsibilities as well. As a matter of fact, if the sponsoring agencies carry out their obligations to the blind and visually impaired the above-mentioned requirements for candidates will become, automatically, a part of the total program of preparation.

First, we are vitally concerned that a staff member be trained in the skills of developing professional opportunities for blind persons. The techniques are different from those in industrial, agricultural, or clerical placement and we might as well come to a realization of that fact early in the game if we are going to assume our responsibilities of adequately opening new job opportunities at this level.

Second, the agency must establish sound policies regarding its program of professional training for blind people. It must set criteria for the individual to meet. It must realize that requirements today in professional employment frequently go beyond the four- or six-year college training program and it is our obligation to provide whatever training is required to enable the blind person to have the best possible opportunity for success in his chosen profession. Thus, the agency's policies should be well established and known to the staff as well as to the blind person which it is serving. These policies must be flexible enough to meet the changing requirements for professional training.

Part of that policy must concern pregraduation activities, bearing in mind that the agency staff cannot go to an employer of professional personnel and demonstrate the blind person's skills and abilities as he can demonstrate the competency of a blind person on a drill press, a lathe, etc. Long-range plans must be undertaken at an early stage. The agency personnel must be in constant contact with the college or university to make sure that the blind person is meeting the requirements of the course. Substitution of courses should be an exception rather than a common practice. The agency should plan to permit the blind student to attend regional or national meetings in the area of his professional training where employer contacts can be made during the junior or senior year (or both). The placement advisor at the college or the chairman of the department will assist a good student also to direct his efforts in the right direction.

Services must go beyond the mere acquisition of a diploma at the postgraduate level. The individual entering a professional occupation may require additional reader service from a month to perhaps a year afterward. He may require the acquisition of manual material, rules, regulations, etc., in braille or in large print in order for him to work as independently as he can. The agency must be prepared to meet these exigencies and to provide the necessary tools, equipment, and services to the client.

These are fundamental to a sound program of placement of blind persons in professional occupations; yet there is one provision we have failed miserably to secure. The student does not get it in his academic courses, and in most instances the agency staff member has little real skill in it; that is the preparation of a good written application and profile for an individual to submit to a prospective employer prior to the employment interview. This is a universal weakness of placement programs, and exists not only with our blind candidates, but with sighted candidates as well. We cannot overemphasize the importance of writing up a good application and an outstanding profile.

OTHER VALUES TO BE CONSIDERED

There are other values which must be considered in the total picture of developing placement opportunities for blind persons in these areas of employment. As we have stated, the technique is not job demonstration; rather, the technique is to make available open doors (i.e., job interviews) for the applicant after he has completed his professional training. Preparation for this is required long before he receives his diploma.

Both the staff member of the agency and the blind person must have some idea of the potential entrance level for a blind person in any professional occupation. Too frequently we encounter persons who, fresh out of law school, expect to be $25,000-a-year trial lawyers or, fresh from a school of journalism, expect to win the Pulitzer Prize for the outstanding news story of the year. Need we say that these are slightly unrealistic approaches to the solution of an employment problem? The starting point is, of course, well down the organization ladder unless one has the good fortune to marry the boss's daughter, join a family organization, or inherit the family business. In practice these situations rarely occur either to the blind or the sighted.

Our study has revealed that two areas are of vital importance to the blind person:

1. His ability to speak in public once he has achieved professional status. Many of the those interviewed told us that they were miserable before an audience but in climbing the ladder of success it was necessary for them to deliver papers or to speak before groups occasionally. The most common solution, they found, was to join Toastmasters or Toastmistresses International where they had an opportunity to learn to speak and to become proficient in holding an audience.
2. The ability to communicate via the written word to colleagues within the organization, to subordinates, to customers, etc., was vital.

Both the blind person and the staff member must be aware that the door can only be opened for an interview; once the blind person steps through that door, he and he alone can grasp or lose the opportunity. Let me cite but one example.

A blind person seeking an opportunity to teach in our public school system has an interview with the school superintendent arranged for him by his counselor. The counselor can lay some ground work and give some general interpretation regarding the manner in which a blind person can function, but it remains for the blind person himself to demonstrate clearly these facts to the superintendent by his competency. After the interest of the superintendent is assured, he is faced with the need for convincing the school board of his ability.

It is natural and normal for these persons to resist the employment of a blind teacher for their children; yet the candidate for employment is the only one who can make the strongest bid to change this attitude. Once the door is open and the blind person walks through, he must go with confidence, knowing that he has met the standards of personal management and competency set down by the agency; in its turn, the agency or other resources will have provided him with the best possible professional training for the position he seeks. With this knowledge in hand, and with competency in self-expression, he has overtaken the major hurdles.

PROFESSIONAL AREAS OF PLACEMENT

We examined in detail and with some depth 15 professional areas of employment. I will not attempt to detail them at this time, except to say that we found that in each of the areas problems existed, that many solutions were found, but that not all problems have necessarily been solved. From the interviews and the analysis of the data gathered we were able, for each of the 15 areas, to include what we have termed a "psychological portrait" of the kind of blind person who has the best chance of succeeding in that particular area.

Rather than to detail our findings in each of the specific areas, let me give a partial listing, with a few incidental comments in the hope that you may find it desirable to read the entire volume.

1. Legal and related employment activities including judgeships
2. Scientific and related occupations in the fields of physics, chemistry, mathematics, research, and electronic computer programming
3. Teaching in public and private schools at the elementary and secondary levels and college teaching, both undergraduate and graduate
4. Social work including general social casework, psychiatric social work, medical social work, and so on
5. Journalism and the communication arts including the theater, radio, television; music including solo appearance and/or as participant in an organized musical group
6. Health and related fields including occupational therapy, physical therapy, osteopathy, chiropractics, etc.
7. The ministry in its various denominational aspects
8. Business at the management or employee training levels.

In each of these areas we found groups of blind persons who were firmly convinced that they could do one thing and not the other, while at the same time we were interviewing other blind persons in the same profession who were doing that which the first group said could not be done and had some hesitancy in doing that which group one was doing. Let me cite one example. A number of blind attorneys stated clearly that they found it impossible to practice in the courts as trial lawyers, that this area was wholly unsuited for a blind person; that they believed the judge and jury might be prejudiced to avoid giving the appearance of being sympathetic to a blind lawyer. Their practice was limited, therefore, to legal counseling, contracts, real estate, and the like.

But we talked also to a number of attorneys who felt that the only solution was to practice as a trial lawyer. Many of them found novel ways to meet the competition of their sighted colleagues in the courts. The reader is referred to the full study for further detail.

Let me summarize a few of the salient points and underline an essential fact.

In the placement of blind persons in the professions, we have only begun; we do not, as yet, know all the techniques. We hope that what we have done thus far is but an initial step in making it possible for the volume to grow in worth to every individual who is blind and may be considering a profession, or to the counselor who must assist blind people in making decisions which will ultimately dominate their lives.

In the placement of a blind person in a profession it is not possible for the counselor or the agency to demonstrate his competency. This must be determined through careful screening of the applicant along the lines suggested earlier. The responsibility for devising a sound on-going and flexible policy for the applicants devolves, inevitably, on the agency. Both the blind person and the agency must be prepared both before and after graduation for continuance of services as they may be required.

The emphasis is on the person. This means in practice the full development of all his personal skills and competencies, and the provision of the best possible training, whether four, six, or eight years in duration. The additional skills in communication, public speaking, personal grooming, mobility, etc., cannot be overlooked, but with it all we must be concerned with packaging the finished product in the most attractive manner to make him a marketable commodity in the professional employment market.

Finally, as one who has been interested and who has participated in professional placement for a number of years, I am fully convinced that with the present emphasis on specialization and professionalization we are on the threshold of a great new opportunity for the placement of the blind in professional occupations.

SECTION III

RADIO AND ELECTRONIC AIDS

CHAIRMAN: ROBERT W. GUNDERSON
New York Institute for the Education of the Blind, Bronx, New York

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RADIO-ELECTRONICS FOR THE BLIND

ROBERT W. GUNDERSON
New York Institute for the Education of the Blind, Bronx, New York

PART I

As an instructor of a class in radio theory and practice at The New York Institute for the Education of the Blind (NYIEB), I have often been questioned on the value of such a course to blind students. Twenty-seven years ago, when this course was first organized at the Institute, it was decided to try it as an experiment; since that time it has become so sucessful and so popular that it is now a regular elective subject. Many blind students study radio and electronics as a hobby, obtain an amateur license, and then use radio as a source of contact with sighted operators all over the world. Many others have become gainfully employed as engineers, electronic testers, inspectors, and assemblers. Before explaining some of the methods employed in teaching radio and electronics to the blind, let us first enumerate some of the advantages gained in such a program.

When studying a subject in science, we learn and use mathematical thought and analysis. In other words, we can contribute to the student's general education and at the same time train him to think clearly, surely a life-long asset to him. Building such electronic equipment as radio receivers, transmitters, test equipment, computers, etc., adds to an individual's manual dexterity and self-confidence—characteristics useful to persons blind and sighted alike.

A great many of our present-day electronics engineers and technicians learned these fundamental skills and habits of thinking as radio amateurs. Through the medium of amateur radio, one can talk with other amateurs in all parts of the world, using the simplest types of transmitting and receiving equipment. A transmitter may have less power than a good home radio, yet can communicate over long distances at the higher radio frequencies.

I have always maintained (and still do) that our chances of finding suitable employment depends directly upon the number of our acquaintances. The man known to 100 persons, who may think of him at the right moment, is ten times more likely to find employment as the man known to only ten people. This is particularly true in the case of the blind technician whose circle of acquaintances is usually limited. Amateur radio offers a means to widen the blind person's circle of acquaintances.

There are some 200,000 radio amateurs in the United States and over 50,000 in other countries. These amateurs represent a great organization of common interest. Innumerable acquaintances are made, many of them international in character. It is here that amateur radio, while not actually a vocation, is indeed a most important vocational aid, and the more so in the case of the blind technician.

Many blind technicians began their scientific education as radio amateurs and have gone further and become scientists, engineers, technicians, assemblers, testers, and inspectors. Others have gone into technical writing, teaching (of both sighted and blind technicians), and computer programming. Yet, even with these encouraging developments, we are still confronted with three major difficulties in teaching radio and electronics to the blind:

1. The lack of suitable radio literature in braille
2. The need for classroom aids for tactual demonstration of circuits and operating principles
3. The need for electronic test equipment adapted to the needs of the blind.

The need for electronics literature is very pressing. Numerous attempts have been made to transcribe standard inkprint textbooks into braille. But, most inkprint texts rely on the use of figures and diagrams to illustrate and to supplement the text. A typical example of such a work was *The Radio Amateur's Handbook,* transcribed by the American Red Cross in 1936. The simpler diagrams were embossed with braille symbols and letters in the appropriate places. While this system may work for very simple circuits, those of even moderate complexity become a hopeless jumble of lines and dots. Despite the hard work involved in this pioneer effort, the resulting book was practically useless.

In an effort to make it easier for blind applicants to qualify for commercial radio and amateur licenses, the writer proposed in 1937 that blind applicants be allowed to write word descriptions of the circuit diagrams when taking Federal Communications Commission (FCC) examinations. This method was approved by the FCC and is now the standard procedure for examining blind applicants. Indeed, this method of describing circuits has worked so well that we now use it as standard teaching technique for describing the construction of electronic equipment to students at NYIEB. *The Radio Amateur's License Manual* (of questions and appropriate answers) was prepared with these special word descriptions of circuits at the Institute in 1938. This was the only electronics literature we had until 1950 when the writer organized *The Braille Technical Press,* the only braille radio and electronics magazine to date. This magazine was established as a nonprofit membership corporation in the State of New York, to publish braille electronics literature, talking book recordings, etc., and also to develop suitable auditory test equipment for the blind. In September, 1959, *The Braille Technical Press* began publishing its talking book edition, recorded at 16⅔ rpm. Both versions are published monthly with approximately 500 braille and 160 talking book copies.

Many readers receive both braille and recorded editions, using the talking book record for rapid reading and the braille edition for more thorough study. All the circuits are described verbally; frequently graphs are tabulated verbally also. In some cases a graph is tabulated and drawn (the drawing used merely to represent the shape of the curve).

Subscription to the braille edition is $7 per year, while the talking book edition is $10 per year. However, if the reader is unable to pay, he may receive the magazine free of charge simply by requesting it. The magazine is mailed to almost every country on the globe. It contains departments for the various interests of radio amateur, service technician, "hi-fi" enthusiast, beginner, sound recording technician, experimenter, etc. Other special topics, such as "Fundamental Electronics," and articles describing developments in auditory test equipment, are prepared with the idea of making them available later as bound volumes for blind students.

Auditory Measuring Equipment for Electricity and Radio is now available as a tape recorded work, prepared and distributed by Science for the Blind, Haverford, Pa. There are seven 1800-foot reels, each recorded on two tracks at 3¾ in./sec. Each reel contain articles which have appeared in various issues of *The Braille Technical Press.* Professor T. A. Benham, Director of Science for the Blind, has requested that we issue *Fundamental Electronics* in a tape recorded edition.

Professor Benham founded the *Science for the Blind* recorded magazine in 1957. It is published monthly on one 7-inch 1800-foot reel of magnetic tape, recorded at $3\frac{3}{4}$ in./sec, and contains articles of general scientific interest for all types of listeners. In addition, Science for the Blind offers many extra services such as tape recorded books, lectures, etc., dealing with various subjects, including radio and electronics. Recording for the Blind has a number of recorded books dealing with electronics available for loan on Soundscriber discs; these were read by volunteers. Circuit diagrams are given in word descriptions on these recordings. The books *How To Become a Radio Amateur* and *The Radio Amateur's License Manual* (1952 edition), are also available in Grade 2 braille. The American Foundation for the Blind has recorded the Novice and General Class sections of the *License Manual* on talking book records, at $33\frac{1}{3}$ rpm, along with two sides of code practice transmission. This is the present status of our electronics literature in braille, on records, and on tape.

The Hadley Correspondence School for the Blind is considering the offer of a correspondence course in electronics. Lessons will be sent to students in recorded form on Soundscriber discs. With this continued increase in enthusiasm, we are hopeful that our *Fundamental Electronics* can soon be made available more generally.

The equipment used for tactual demonstration of circuits and operating principles has been given considerable attention at NYIEB. We have a complete radio receiver of the superheterodyne type laid out on a large tabletop, with all components readily accessible. Connectors of various types are provided for making circuit adjustments and measuring circuit parameters such as voltage, current, resistance, circuit gains, etc. In addition, a complete radiotelephone transmitter is made as a breadboard unit with all circuit elements laid out in the same manner.

The blind student entering our program in radio theory and practice first builds simple circuits using breadboard techniques. In addition to mounting all components, doing his own wiring, soldering, etc., he must write up each circuit in his notes and memorize it thoroughly. The construction gradually changes over to chassis techniques, with the students finally using tools such as the drill press, punches of various types, nibbling tools, shears, saws, etc., to fabricate the various chassis layouts.

The auditory measuring instruments devised for the use of the blind are discussed in Part II of this paper.

PART II

AUDITORY TEST EQUIPMENT FOR THE BLIND

The auditory measuring instruments devised for the use of the blind are of two basic types: Wheatstone bridge circuits in which a null or absence of sound is used as the indication; or circuits in which a pitch change is produced by changes in circuit parameters (1). One example is the ohmmeter which has a conventional bridge circuit using a "chopper" and a headset at the center of the bridge instead of a galvanometer (2). The calibrated element is a precision linear potentiometer fitted with a braille scale. The "known" side of the circuit is made up of resistances arranged in decades of ten, i.e., 1, 10, 100, . . ., to 10 MΩ. The operator connects the unknown resistor to the proper terminals, then adjusts the potentiometer and the range selector until a null occurs on the lowest range. By this means, a reading can be made on the maximum full scale position, thus making measurement easy.

Capacitance and inductance bridges are built as simple ac bridges, although provision is made for a linear scale based on multiples of ten (3). AC is supplied to the outer terminals and a headset is connected between the bridge centers.

The so-called subtraction bridge is used for the measurement of very small capacitances (3). This circuit makes use of two oscillators: one fixed, the other variable. The variable oscillator is adjusted to give a zero beat with the fixed circuit when the variable tuning capacitor is at nearly maximum capacitance. When the unknown capitance is connected in shunt with the variable tank capacitor, its value must be "backed down" until the zero beat condition appears again. The variable capacitor is equipped with a dial scale calibrated in terms of the unknown capacitance values. The actual subtraction circuit is made with two crystal controlled oscillator circuits set about 1000 cps apart plus a variable oscillator, all feeding into a common mixer. By this means very accurate measurement is possible, since the "wow" (beating) can be heard when the variable oscillator is very close to zero beat. The subtraction bridge has been made using vacuum tubes and as a transistorized device.

The dc voltmeter consists of a potentiometer and resistance multiplier network; a chopper and headset are used to compare the voltage across the precision potentiometer with the voltage between the common side and the tap on the multiplier (4). Units having sensitivities in excess of 100,000 Ω/v have been built, although most of our equipment has been standardized at a sensitivity of at 20,000 Ω/v.

The ac voltmeter is simply the dc voltmeter (potentiometer-multiplier) with the output of a rectifier/filter fed to the input terminals (4). The ac voltmeter is a peak reading instrument; if rms values are to be measured the voltage across the potentiometer is changed, or the tap on the multiplier is changed.

The method used to measure dc amperes is the same: the voltage across the precision calibrated potentiometer is nulled against the voltage produced across a precision resistance through which the circuit current is flowing (5). The chopper and headset (or an amplifier/loudspeaker instead of the headset) provide the null indication.

An ac ammeter of the clamp-on or hook-on variety can be made to work in conjunction with the ac voltmeter circuit by using a current transformer, as with conventional meter movements (6). The output of this transformer is simply connected to the ac voltmeter with its calibrated scale marked off in terms of ac amperes. An instrument of this type is invaluable in servicing electrical appliances.

Standard D'Arsonval meter movements can be read by connecting these movements in a comparison arrangement, in which the voltage across the meter movement is compared to the voltage across the precision potentiometer which is equipped with a scale calibrated in terms of the full scale reading on the meter movement (7).

The Auditory Circuit Analyzer (see Figure 1) or multitester combines in a single unit the functions of an ammeter, ohmmeter, and ac-dc voltmeter (8). The ranges of the ammeter are 0-1 ampere, and 0-100, 0-10, 0-1, 0-0.1, 0-0.01, 0-0.001, and 0-0.0001 milliamperes. In other words, this instrument reads from 1 A to 0.1 μa. The ohmmeter ranges are: 0-1, 0-10, 0-100, 0-1000, 0-10,000, and 0-100,000 Ω, and 0-1 and 0-10 MΩ. The voltage ranges are: 0-1, 0-5, 0-10, 0-50, 0-100, 0-500, and 0-1000 volts dc at a sensitivity of 20,000 Ω/v. Provision is also made for using the unit on ac by introducing a diode and a capacitor into the dc voltmeter circuit to make the instrument a peak reading ac voltmeter. A polarity reversing switch is connected across the voltage source supplying the potentiometer so that voltages negative or positive with respect to ground can be measured. The case of the analyzer is connected to common ground in the circuit under test.

The dc vacuum tube voltmeters use the conventional bridge type tube circuit, with the metering circuit connected between the cathodes (9). If the instrument uses the standard visual meter movement, the potentiometer and chopper simply compare the meter's voltage drop to that of the potentiometer. The voltage across the potentiometer is made equal to the

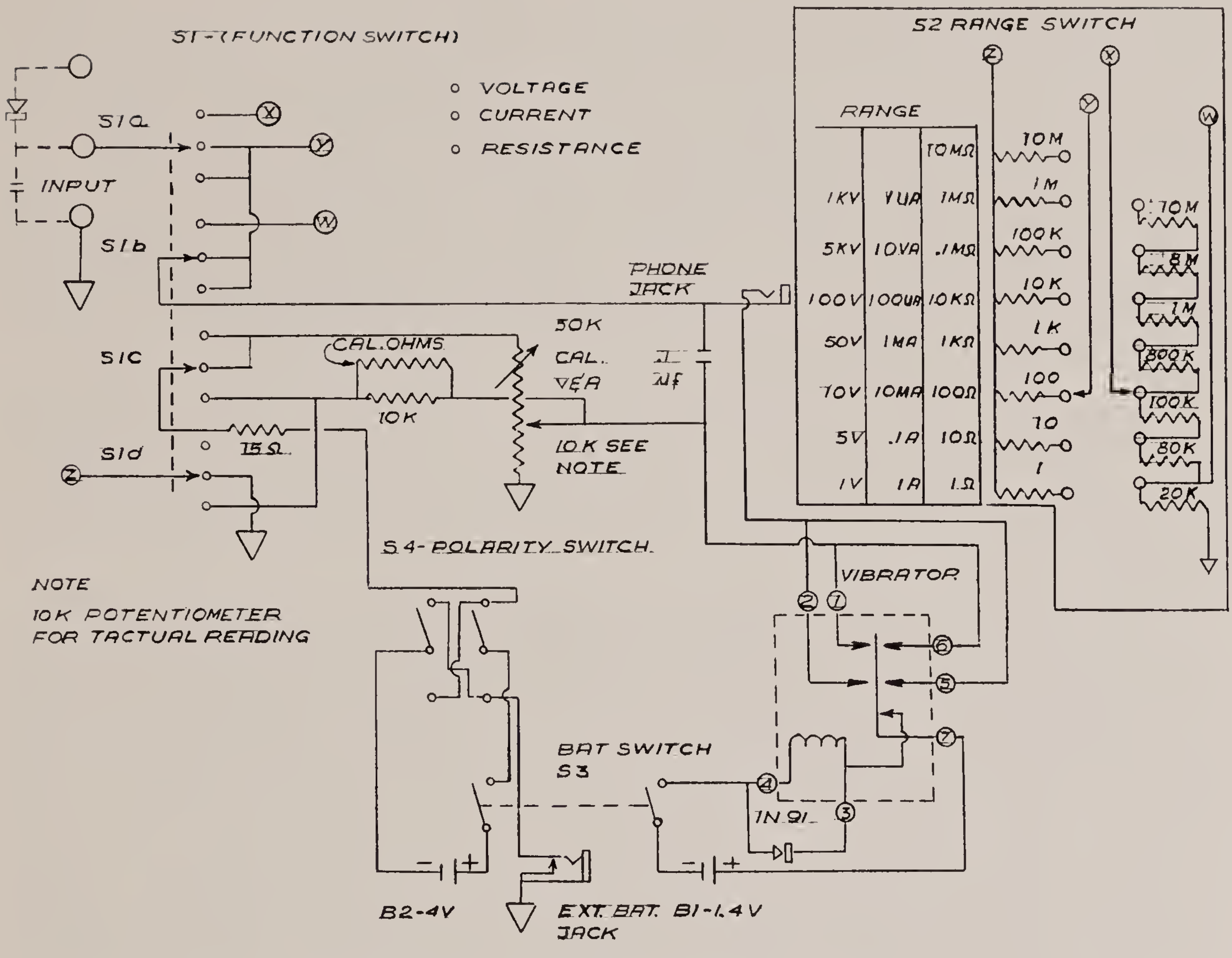

FIGURE 1a Auditory Circuit Analyzer

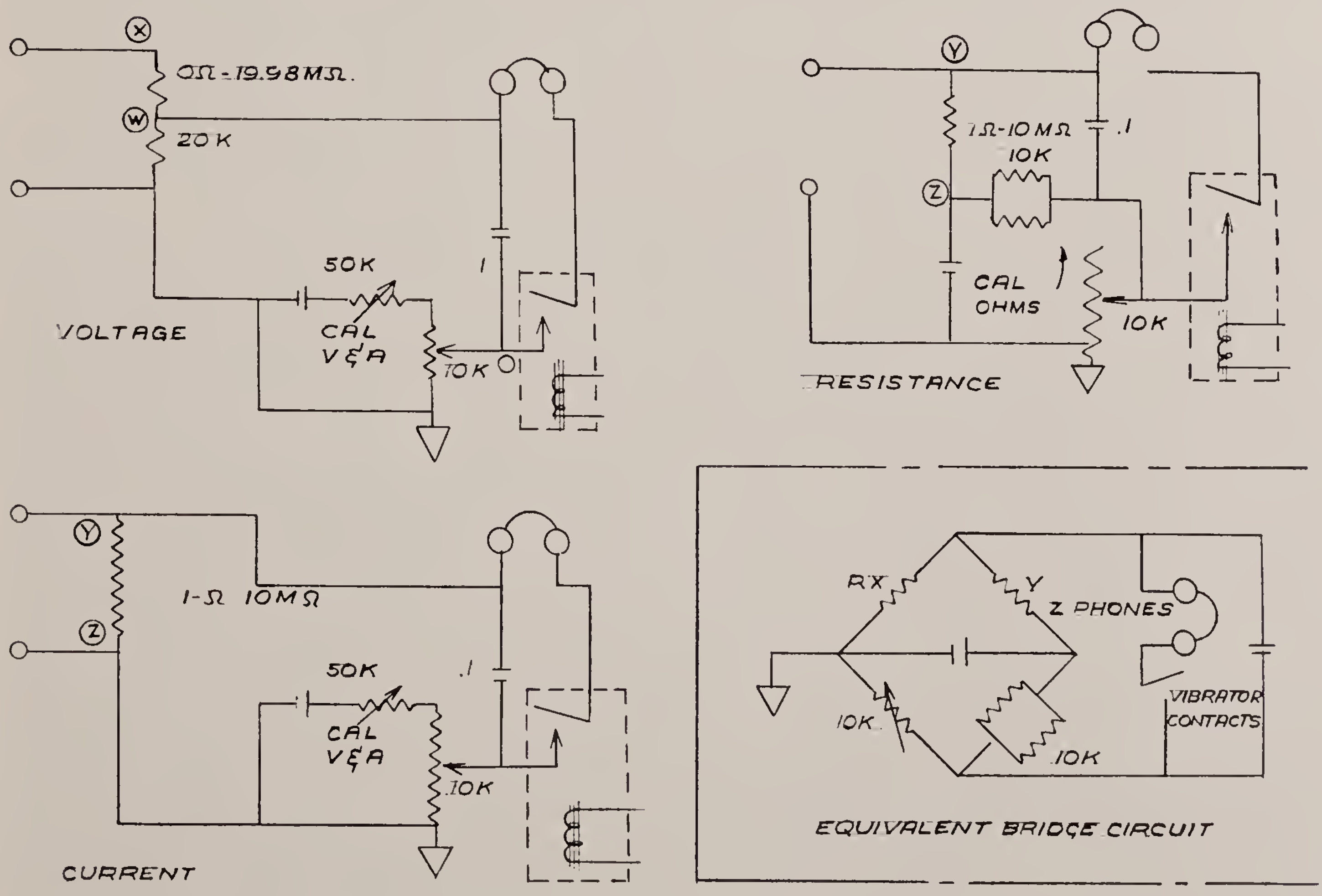

FIGURE 1b Auditory Circuit Analyzer Circuit Breakdown for Three Function Switch Position

full scale voltage of the meter movement, and the calibrated potentiometer scale is read in terms of the particular voltage range to which the instrument is switched. In the case of the ohms ranges, a chart of resistance (or scale reading on the potentiometer) versus some low voltage value included in the meter's range must be made because these ranges are not linear. Instruments of this type have been built using just the auditory indicator; others of the commercial variety are simply adapted by adding the potentiometer and chopper.

Audio frequency vacuum tube voltmeters are made with the same indicating system; the calibrated potentiometer and chopper are used to measure the voltage drop across the visual meter, or across a resistor substituted for it (10).

Commercial tube testers have been adapted for the use of the blind (10). The roll chart in the older models must be brailled. The newer instruments use standard IBM cards which fit the built-in matrix; these cards must be prepared with the appropriate tube type numbers in braille. When the card is inserted all switching is accomplished automatically. For tube testers we have chosen to use the indicating meter in the instrument as the voltage standard, translated simultaneously into sound via the auditory adaptor so that a sighted customer may also discover the condition of his tubes as they are tested by the blind service technician.

Other instruments using the null principle include: a phase meter, Q meter, deviation meter, transistor testor, rf wattmeter (11), rf antenna bridges (11), in-circuit checker (to measure electrolytic capacitors), resonance meter, and special bridge circuits to compare time constants (of large capacitors such as electrolytic units, etc.).

A very simple continuity meter has been developed using a conventional relaxation oscillator with the resistance, inductor, capacitor, diode, etc., under test connected in series with it (12). If the resistance is high the pitch of the sound from the loudspeaker output is low; a low resistance yields a high pitched output signal. This instrument is invaluable for checking the polarity of many components such as semiconductor diodes, transistor junctions, electrolytic capacitors, etc. This unit is also voltage sensitive; it may be connected in shunt with some low value resistor and connected into the plate circuit of a class C rf stage in a radio transmitter and used as a tuning indicator (13). This unit may also be connected to a photoelectric cell as a light indicator. An external neon lamp may be connected across the leads also to detect high frequency fields. This configuration has been termed "The Auditory Neon Lamp" (13). The more intense the ionization (due to the more intense rf field), the lower the internal resistance of the external lamp will be, and the higher the pitch of the af output. This device will also serve as a rather good tuning aid for the blind ham radio operator.

A device which we have called the "Transistorized Auditory Gimmick" makes use of an oscillator preceded by a dc amplifier whose output adjusts the operating bias for the oscillator stage of a transmitter, and hence its operating frequency (14). If the input to the dc amplifier is polarized properly with respect to the indicating meter movement in the transmitter, the pitch of the oscillations will rise as the meter pointer moves up scale; the pitch will decrease with a lower meter reading. The blind operator can tell readily which way the meter moves as he changes the tuning of the various stages of the transmitter. This instrument also doubles nicely as an absorption type wavemeter when the input to the dc amplifier is fed by a diode working from a tuned input circuit adjusted to resonance with the operating frequency. The Gimmick also functions as a remote tuning indicator if a telephone pickup coil is inductively coupled to the laminations of an iron cored filter inductor; the output of this coil is rectified, filtered, and fed to the Gimmick (as its power supply), or to the input of the dc amplifier. The greater the current through the filter choke the greater the induced voltage in the coil, and the greater the pitch change. The pickup coil, rectifier, and filter have also been incorporated into the auditory dc voltmeter; the dc voltage is read in terms of the current flowing in the plate circuit of the amplifier under test.

Variations on the Gimmick circuit have been made by a number of investigators to increase the precision of readings of current (15). In one method a precision potentiometer (whose voltage is adjusted to equal the full scale voltage swing of the visual meter movement) is included in the circuit with a press-button switch. When the transmitter has been adjusted the pitch produced by the voltage drop across the meter is noted and the push button depressed; this connects the calibrated potentiometer into the circuit in place of the meter movement. The dial is adjusted to give the same pitch in the transducer and the scale is read for an actual current value. Comparison tone circuits can also be included in this instrument by connecting preset variable resistors across the input and switching them in or out to compare pitches produced at different current values. Any number of tones can be used by including a single pole, double throw push-button switch, and a high resistance rheostat, for each tone generator. When all the switches are in normal position the input to the Gimmick is connected to the terminals of the meter in the transmitter.

Instruments such as auditory grid dip oscillators use the dc amplifier/

oscillator combination as the audible indicator (16). Completely transistorized grid dip oscillators have been developed also. In the case of tube type grid dip oscillators, a multivibrator operating at audio frequencies receives its bias from the rf oscillator; as the bias changes (due to loading of the tuned circuit by an external resonant circuit) the pitch produced in the headset by the multivibrator provides an audible indication of the change. Commercial grid dip meters have been adapted by including the Transistorized Auditory Gimmick inside the unit and either a small loudspeaker or a headset in place of the meter movement.

The Gimmick circuit may be used in conjunction with photoconductive type photocells of the cadmium sulphide variety; here it is made up as a combination probe/light source for finding a meter pointer. This system provides excellent sensitivity when connected to the base emitter circuit of the dc amplifier in series with a voltage supply. It is necessary to mount the probe on a swivel and to equip the outside edge of the instrument with dots corresponding to the markings on the meter face. The accuracy of this system does not begin to compare with bridge methods for most applications.

A rather interesting volume level indicator has also been developed using a transistorized af oscillator and a second transistor connected as an unbypassed emitter resistor (17). The second transistor has a very high resistance and its base is left floating; the resistance is so high, in fact, that degeneration produced across it prevents the oscillator from functioning. A diode, potentiometer, and filter capacitor are arranged to take off a small portion of the audio signal to be measured; this portion serves as the bias for the second transistor in a direction to cause it to conduct heavily. Degeneration thus no longer obtains and the oscillator starts to operate. The instrument is silent until some predetermined voltage is reached, whereupon the oscillator sounds an alarm to tell the recording operator that volume level is too high.

Another meter reading device employs a four-diode bridge (diode modulator or chopper), working into an audio amplifier whose output is rectified and drives the biasing voltage for a multivibrator (18). This device involves considerable complexity and works about as well as the Transistorized Auditory Gimmick.

Further variations involve the use of two rf oscillators in a beat frequency configuration; one is reactance modulated by the dc voltage drop across a meter movement (19). These give good performance, although they are rather complicated to operate.

Meter readers using capacitively coupled devices have been in use for many years (20). By means of these instruments, a conventional piece of test equipment may be adapted simply by mounting a capacity probe above the glass on a meter face, using the capacitance formed between the meter pointer and this probe to detune one of the high frequency oscillators in a beat frequency oscillator arrangement. This will produce a "howl" in the loudspeaker; maximum pitch indicates that maximum detuning has taken place. The probe is connected with a pointer which rides over a brailled scale on the edge of the indicating meter so the blind operator can read the visual meter in terms of the braille scale. A number of commercially available instruments such as multitesters, vacuum tube voltmeters, tube testers, etc., have been modified for use with this adaptor. The writer has had no experience with this type of device.

A number of rather specialized devices have also been proposed; some of these are currently under development. Among these are:

1. A few electronic thermometers; in these devices a thermistor is used as a bridge arm and an af source used as the ac signal. The bridge feeds either directly into a headset, or into an amplifier and then a headset (to increase sensitivity). The scale of the potentiometer is calibrated in degrees Fahrenheit or Celsius.
2. An electronic stroboscope using a photoelectric cell and light source powered from a dc source in which the light is reflected back from the stroboscope card and excites the photocell. The output of the photocell feeds an amplifier and loudspeaker. At the same time, a source of 60 cps ac is impressed upon another input channel so that both signals (from the photocell and from the secondary source) are mixed. If there is a beat between these signals the operator knows immediately that the rotating turntable is out of step (i.e., fast or slow). Placing a slight load on the turntable will decrease its speed, and if this brings the two signals back into synchronization, the turntable is fast; if the two signals move further apart, the turntable is slow.
3. Numerous electronic null indicators in the form of symmetrical oscillators and electronic choppers (both vacuum tube and transistor types are included) are also receiving attention in efforts to replace the mechanical chopper with something better, although at this writing it would appear difficult (if not impossible) to do so.

This list of test instruments is indeed impressive. Considerable work has been done in an attempt to devise yet newer and more precise instruments. It is with regret that I must report, however, that most of this equipment is not generally available. The Auditory Circuit Analyzer is obtainable through the American Foundation for the Blind. We can only hope that additional equipment may be forthcoming from this and other sources for the use of blind persons interested in electronics. Most of our test equipment can also be used by sighted technicians for it is quite rugged and will, in most instances, withstand heavy overloads, indeed far heavier than conventional meter movements.

It is also most encouraging to note that many sighted technicians have built auditory test instruments: the Auditory Circuit Analyzer, grid dip oscillator, Auditory Gimmick, and so on. They find that using this equipment is often easier, and far less dangerous to human life, than conventional instruments.

We have come a long way in the development of test instruments for the visually impaired technician. It is with a feeling of considerable pride that the writer can say that the *Braille Technical Press* has become a clearing house for many of these ideas, suggestions, and developments—all made by its readers over the world. Much remains yet to be accomplished, for the average blind person interested in preparing himself for an engineering or scientific career is often discouraged by educators who are not aware of how much can be accomplished. We must, somehow, and within the next few years, educate the instructors in various engineering schools to what can be done by a blind student. This is an area in which each of us can teach. Indeed, unless we make some such common effort, we can never hope to establish blind scientists, teachers, engineers, and technicians on an equal footing with sighted people.

There is a chronic and continuing need for people with scientific orientation in every nation. The scarcity of trained personnel may even constitute a real crisis in the life of society. It can be turned into a blessing in disguise, however, if we begin now to utilize fully every means to train and equip every interested and skilled person who wishes to vanquish this problem; the lack of vision no longer constitutes any barrier to anyone who wishes seriously to enter the world of science.

REFERENCES

1. Gunderson, R. W., "Test Equipment for the Blind," *Braille Tech. Press,* Vol. 1, No. 1, (March, 1950).
2. Gunderson, R. W., "Simple Auditory Ohmmeter," *Braille Tech. Press,* Vol. 1, No. 3, (May, 1950).
3. Evans, Q., "A Simple Capacitance Bridge," *Braille Tech. Press,* Vol. 9, No. 11, (November, 1958).

———, "A Bridge for Electrolytic and Other Large Value Capacitors," *Braille Tech. Press,* Vol. 10, No. 4, (April, 1959).

———, "What's New in Capacitance Bridges," *Braille Tech. Press,* Vol. 11, No. 7, (July, 1960).

Gunderson, R. W., "Simple Auditory Capacitance Checker," *Braille Tech. Press,* Vol. 1, No. 9, (November, 1950).

———, "Capacitance Checker for the Measurement of Small Condensers," *Braille Tech. Press,* Vol. 2, No. 5, (May, 1951).

———, "Simple Capacitance Bridge," *Braille Tech. Press,* Vol. 2, No. 11, (November, 1951).

———, "Auditory Inductance Bridge," *Braille Tech. Press,* Vol. 3, No. 8, (August, 1952).

———, "Transistorizing The Capacitance Bridge," *Braille Tech. Press,* Vol. 11 No. 9, (September, 1960).

Wartenberg, S., "The Poor Man's Bridge," *Braille Tech. Press,* Vol. 1, No. 5, (July, 1950).

4. Gunderson, R. W., "Auditory AC and DC Voltmeter," *Braille Tech. Press,* Vol. 1, No. 2, (April, 1950).

———, "Improved AC Voltmeter Design," *Braille Tech. Press,* Vol. 1, No. 7, (September, 1950).

———, "Auditory DC Voltmeter," *Braille Tech. Press,* Vol. 2, No. 6, (June 1951)

———, "High Impedance AC Voltmeter," *Braille Tech. Press,* Vol. 2, No. 8, (August, 1951).

———, "High Impedance Multi-Range AC and DC Voltmeter," *Braille Tech. Press,* Vol. 3, No. 7, (July, 1952).

Sparks, A., "A Versatile Voltmeter and Milliammeter," *Braille Tech. Press,* Vol. 3, No. 5, (May, 1952).

5. Gunderson, R. W., "A Simple Auditory Milliammeter," *Braille Tech. Press,* Vol. 1, No. 1, (March, 1950).

———, "Auditory RF Ammeter," *Braille Tech. Press,* Vol. 2, No. 2, (February, 1951).

Quay, E., "Transistorized Milliammeter," *Braille Tech. Press,* Vol. 7, No. 10, (October, 1956).

6. Gunderson, R. W., "Clamp-on Ammeter Adaptor for the Auditory Circuit Analyzer," *Braille Tech. Press,* Vol. 9, No. 3, (March, 1958).

———, "Auditory S-Meter for the Communications Receiver," *Braille Tech. Press,* Vol. 3, No. 3, (March, 1952).

7. Gunderson, R. W., "Auditory Meter Reader," *Braille Tech. Press,* Vol. 3, No. 4, (April, 1952).

———, "Adapting Standard Multi-Testers for the Use of the Blind," *Braille Tech. Press,* Vol. 4, No. 10, (October, 1953).

———, "The Wigginton Voltage Tester," *Braille Tech. Press,* Vol. 4, No. 12, (December, 1953).

———, "Adapting the Eldico Antennascope," *Braille Tech. Press,* Vol. 5, No. 1, (January, 1954).

———, "Thermionic Tuning Indicator," *Braille Tech. Press,* Vol. 6, No. 12, (December, 1955).

———, "A Transistorized Meter Reader," *Braille Tech. Press,* Vol. 8, No. 1, (January, 1957).

———, "A Transistorized Auditory Gimmick," *Braille Tech. Press,* Vol. 9, No. 7, (July, 1958).

———, "Converting Visual DC Vacuum Tube Voltmeters for the Use of the Blind," *Braille Tech. Press,* Vol. 9, No. 9, (September, 1958).

———, "The Reading of Visual Meters By the Voltage Comparison Method," *Braille Tech. Press,* Vol. 9, No. 9, (September, 1958).

———, "Increased Sensitivity for the Transistorized Auditory Gimmick," *Braille Tech. Press,* Vol. 10, No. 9, (September, 1959).

Sladky, Warren, "The A. M. R. Revived," *Braille Tech. Press,* Vol. 8, No. 10, (October, 1957).

8. Gunderson, R. W., "The Auditory Multi-Tester," *Braille Tech. Press,* Vol. 12, No. 4, (April, 1961).

9. Evans, Q., "Auditory AC and DC Vacuum Tube Voltmeter," *Braille Tech. Press,* Vol. 10, No. 11, (November, 1959).

Gunderson, R. W., "Slide-Back Vacuum Tube Voltmeter," *Braille Tech. Press,* Vol. 3, No. 9, (September, 1952).

10. Gunderson, R. W., "Tube Testing," *Braille Tech. Press,* Vol. 4, No. 1, (January, 1953).

———, "AC Vacuum Tube Voltmeter," *Braille Tech. Press,* Vol. 4, No. 7, (July, 1953).

———, "The RCA WT110A Automatic Tube Tester," *Braille Tech. Press,* Vol. 10, No. 6, (June, 1959).

11. Gunderson, R. W., "Building and Using the Antennascope," *Braille Tech. Press,* Vol. 2, No. 1, (January, 1951).

———, "An Inexpensive RF Wattmeter for the Amateur Station," *Braille Tech. Press,* Vol. 12, No. 2, (February, 1961).

12. Gunderson, R. W., "Simple Continuity Meter," *Braille Tech. Press,* Vol. 1, No. 6, (August, 1950).

———, "Improved Continuity Meter," *Braille Tech. Press,* Vol. 7, No. 2, (February, 1956).

Lace, A., "The Poor Man's Continuity Meter," *Braille Tech. Press,* Vol. 4, No. 12, (December, 1953).

Spencer, C., "Modifying the Auditory Continuity Meter," *Braille Tech. Press,* Vol. 6, No. 1, (January, 1955).

13. Gunderson, R. W., "Auditory Neon Light," *Braille Tech. Press,* Vol. 4, No. 1, (January, 1953).

Lynn, D., "Operating The Collins 32V-Series Transmitters by Ear," *Braille Tech. Press,* Vol. 12, No. 10, (October, 1961).

14. Gunderson, R. W., "Increased Sensitivity for the Transistorized Auditory Gimmick," *Braille Tech. Press,* Vol. 10, No. 9, (September, 1959).

15. Lynn, D., "Accuracy with the Transistorized Auditory Gimmick," *Braille Tech. Press,* Vol. 11, No. 12, (December, 1960).

16. Gunderson, R. W., "Auditory Grid Dip Oscillator," *Braille Tech. Press,* Vol. 2, No. 3, (March, 1951).

———, "The B and W Model 600 Grid Dip Oscillator," *Braille Tech. Press,* Vol. 7, No. 4, (April, 1956).

———, "Transistorized Auditory Grid Dip Oscillator," *Braille Tech. Press,* Vol. 13, No. 1, (January, 1962).

Lace, A., "Unusual Grid Dip Oscillator Design," *Braille Tech. Press,* Vol. 3, No. 12, (December, 1952).

Swail, J., "Adapting the Millen 90651 Grid Dip Oscillator," *Braille Tech. Press,* Vol. 7, No. 4, (April, 1956).

17. Gunderson, R. W., "Transistorized Auditory Volume Level Indicator," *Braille Tech. Press,* Vol. 10, No. 2, (February, 1959).
18. Dascenzo, J., "The Dazie Meter," *Braille Tech. Press,* Vol. 7, No. 5 and 6, (May and June, 1956).
19. Hallenback, C., "A Zero-Pitch Null Indicator," *Braille Tech. Press,* Vol. 7, No. 8, (August, 1956).
20. Peterson, LaV., "The R. E. I. Adaptor," *Braille Tech. Press,* Vol. 12, No. 7, (July, 1961).

TWO METERING DEVICES FOR THE BLIND RADIO AMATEUR

DALLAS W. LYNN
Lynn Clinic for Physical Therapy, Dunn, North Carolina

Progress in the development of mobility devices, of reading machines, and indeed of nearly all other apparatus adapted to the special needs of the visually impaired is almost synonymous with progress in electronics. We may look in grateful wonder at the amount of time, energy, and enthusiasm expended by our seeing associates toward meeting these needs. But we may also wish to concern ourselves with electronics so that we may understand better the progress being made.

In this paper two metering devices useful to those blind persons interested in electricity and electronics are to be described. The viewpoint taken is not that of the electronics engineer, but rather that of the blind radio amateur; and so it will not be irrelevant perhaps to begin by expressing a personal attitude toward "ham radio" and blindness.

The operation of an amateur radio station can be a challenging and completely satisfying hobby to the visually impaired. Its appeal can be nearly universal, for while it offers great rewards to the most modest amateur, its farthest horizons may be beyond even the most gifted. If you wish only to throw a switch and talk with your friend across town you need do no more. On the other hand, if you wish to design and build your entire installation, or indeed even make some notable contribution to the electronics art, thousands of your fellow amateurs will gladly pass on to you the fruit of their experience.

This very diversification, inherent in the hobby, beckons to the blind person as to the seeing. The bond among amateurs may be mere conversation, and comradeship; or it may be mutual interests in constructing equipment or in planning circuits.

To become a radio amateur today is well within the resources of many interested blind persons. There is a certain amount of knowledge to acquire and a federal examination to pass; but at least the literature is now available. Hundreds of blind persons who are already licensed prove it can be done.

The road has not always been so smooth. Until recent years there was in the United States practically no relevant literature either in braille or on recordings; the need is still acute. But certain developments, particularly during the past decade, have added considerably to the supply of pertinent reading matter and have added even more to our hopes for the future.

The break-through came in March, 1950, with the first issue of *The Braille Technical Press;* this magazine continues to make its monthly appearance in both braille and talking book form. In 1953, Mr. Gunderson, the editor (a blind radio amateur), arranged for the embossing of two useful books by the American Printing House for the Blind: *How to Become a Radio Amateur,* and *The Radio Amateur's License Manual.* More recently, Professor Thomas Benham (also a blind radio amateur) has made available on magnetic tape certain basic material on electricity and electronics. Still another step forward—and this a giant step indeed—has come from his Science for the Blind. Devoting itself solely to the advancement of higher education among the blind, and relying on the patient work of dedicated volunteer readers from every part of our country, this amazing nonprofit organization is now furnishing books on electricity, radio, and electronics that would never have been provided in any other way. Sighted readers translate electronics diagrams into verbal descriptions, for the most part with painstaking thoroughness. When they have had no previous experience with this kind of "verbalization," they sometimes omit details which the blind listener would like included; but as their experience accumulates, they bring improvement to a method of description of circuitry that is bound to be superior to any other using braille diagrams or raised line drawings.

There are now available not only a nucleus of electronics literature but also many useful aids—specialized devices useful to the blind radio amateur for a fuller mastery of his craft. *The Braille Technical Press* describes such instruments and blind constructors can therefore duplicate them in their own workshops. Two of these devices are at hand.

The first is an auditory volt-ohm-milliammeter, called the Auditory Circuit Analyzer. This instrument, read by hearing and touch (and therefore strictly speaking not entirely auditory) measures electrical resistance, direct voltage and current, and (with a suitable rectifier and filter) peak ac voltage. The model discussed here is our modification of the design. The alteration consists of replacing the original null indicator with one based on a sharp dip in pitch of a loudspeaker tone.

The other device is one we have dubbed the Master Auditory Meter Monitor. With its use the blind radio amateur is able to read (or more accurately, to interpret) the visual meters in his various pieces of equipment. The Monitor provides an aural (i.e., pitch-related) representation of meter reading; in addition it furnishes a series of comparison or reference tones to permit precise adjustment.

THE AUDITORY CIRCUIT ANALYZER

Inspection of the Auditory Circuit Analyzer shows it is housed in a 3-inch by 5½-inch by 10-inch metal case. Mounted on top are the on/off switch, the pointer knob and its braille dial, the function switch (to select voltage, current, or resistance), the range switch (to select the proper scale), and in the original model a jack for headphones. On the rear apron are the meter terminals, the voltage reversing switch (to allow measurement of voltages either positive or negative with respect to chassis), and provision for applying a high voltage battery to sharpen the null when measuring extremely high resistances.

In actual use the unknown quantity to be measured is pitted against the variable, calibrated, battery powered standard. So long as these two quantities are unequal current flows between them, and in the original model the flow is chopped or modulated by the built-in vibrator to produce a distinctive buzzing tone in the headphones. The calibrated source is then varied by manipulating the pointer knob and the reading taken when the buzzing disappears, for now the known has been made equivalent to the unknown value. In the modified instrument unknown and known arms do not go through the headphones/vibrator. Instead, headphones, vibrator, and all other parts of the original indicator circuit have been removed and the two arms connected each to one of the input terminals of a full wave bridge rectifier formed by four matched germanium diodes. The rectifier output feeds into, and governs the frequency of, a special transistorized audio oscillator driving a miniature loudspeaker. In this scheme, the greater the unbalance between unknown and known values, the higher is the frequency of oscillation; thus a null is indicated by a sharp dip in pitch.

The transistorized portion of the circuitry is interesting in its own right. Evolved by Mr. Gunderson as a separate entity, and termed by him the "Transistorized Auditory Gimmick," it is useful just because small voltage changes at its input produce notable pitch changes (i.e., frequency variations) at its output. The direction of the frequency shift is determined by the polarity of the input signal, and the amplitude of the shift by the amplitude of the signal voltage. The input is fed into a dc amplifier utilizing a single npn transistor; this stage provides bias for the following audio oscillator built around a single pnp transistor. The unit is energized by a nine-volt battery.

This transistorized voltage sensitive audio oscillator is incorporated into the revised circuit analyzer by connecting its positive input terminal to the positive output terminal of the full wave rectifier and its negative input terminal to the negative output of the rectifier. With this arrangement, owing to the action of the rectifier, any unbalance between the quantity under test and the calibrated standard must appear at the input to the transistorized indicator as a dc potential that never changes in polarity regardless of the sign of the unbalance. It must follow, therefore, that unbalance will always bring a rise in pitch, whereas balance (the point at which reading is taken) will invariably occur at the dip.

One other difference between the original and the modified version is purely a matter of mechanics. A jack on the rear apron provides for the connection of a high voltage battery to give a sharper null in the measurement of resistances above one or two megohms. This jack has been replaced now by a momentary push-button switch; the extra battery (a 45-volt unit installed internally) is cut in by the switch when needed.

Let us observe our pitch-dipping scheme in operation in the measurement, first of voltage, then of resistance.

Having connected the positive and negative terminals of a battery to the positive and negative terminals, respectively, of the meter we close the on/off switch and manipulate the pointer knob on the calibrated potentiometer until we can bring it to rest at the point where the pitch dips sharply. We can observe the steep rise in pitch on either side of the dip. Noting tactually the position of the pointer at the dip, we find that it rests on the braille mark denoting ten volts. The battery is actually a nine-volt unit, but since our meter has a sensitivity of 20,000 Ω/v the current drain is only 0.5 ma.

We now connect an unknown resistor between the terminals of the meter. Having changed the function switch from voltage to resistance, and having set the range switch on the appropriate scale, we close the on/off switch, and manipulate the pointer knob in search of the dip. The dip is readily discernible and the dial can be read.

In the evolution of this pitch dipping indicator two main obstacles were encountered. The first was the tendency for the oscillator to soar out of oscillation when known vs. unknown arms were much out of balance. This problem was solved easily by using a higher than specified resistance between the collector of the dc amplifier and the base of the oscillator.

The second obstacle was the inevitable voltage drop across the diode and the related problem of obtaining four closely matched units. When the silicon types were used the voltage drop was so great that the null was too broad to be acceptable. By using germanium units it was found that the voltage drop was well within tolerable limits for this application. Even with germanium units great care had to be exercised in matching. Indeed, the full wave bridge rectifier is the critical link in the whole scheme, and unless painstaking selection is made of four germanium diodes that are especially well matched at the point of beginning conductivity (or at the lowest feasible potential) the accuracy of the system will suffer.

THE MASTER AUDITORY METER MONITOR

The Master Auditory Meter Monitor was designed to be read by hearing alone, on the premise that this would be faster and would leave the hands free to make adjustments. (An exception was made for the signal strength meter of the station receiver, which uses a calibrated braille dial as described below.)

When considering the problem of metering several interrelated pieces of equipment (by auditory means) two likely solutions come to mind. One would be to build a separate auditory interpreter for each visual meter. The other would be to construct only a single device, and to switch this among the various metered units as need dictates. A shielded cable could be brought from each piece of equipment for connection to the single auditory instrument, at which point a rotary selector switch could select the particular meter to be monitored.

Where the physical arrangement permits and where the station components are grouped close together, the second approach has much to recommend it. It is by far the more economical, requiring the purchase of only a single collection of parts. Even if several devices were constructed, only one at a time could be listened to purposefully.

To permit interpretation by the ears alone the Meter Monitor provides tone signals to be used in two different ways. First, it emits a tone that varies in pitch directly with meter reading, rising as the reading rises and falling as the reading decreases. Second, it provides on command a number of comparison tones, each preset to be equivalent to a prescribed meter reading; every visually metered circuit can be adjusted to its correct reading, for there is a target tone to aim at.

The heart of the Meter Monitor is Mr. Gunderson's versatile "Transistorized Auditory Gimmick," although it is well concealed by a multiplicity of switches and potentiometers. When this basic configuration is connected across the visual milliammeter in a circuit under observation (for example in the plate circuit of a vacuum tube) the frequency shift of the oscillator will be dependent upon the voltage drop across the meter movement. The greater the voltage drop the wider will be the pitch swing as heard in the loudspeaker, and if proper polarity is chosen the pitch and the meter reading will vary in the same direction.

If our auditory device were to use this basic transistorized circuit configuration in the manner just described, we could tell just by listening whether the circuit current was very high or very low and which way our adjustments were moving it, but we could not know when the current was precisely that desired. This last information could be obtained if we had a reference or comparison tone to "tune" by a tone which would appear at the same pitch as that produced by the meter movement at correct reading. Then by adjusting our circuit until the two tones were identical we could make sure that the reading was that specified.

Such a comparison tone is readily accessible through the simple expedient of replacing the meter movement with a variable resistance across the input to the transistorized unit. The greater this resistance (usually a potentiometer connected as a rheostat), the higher will be the pitch of the comparison tone. Any number of tones may be provided in this manner, each requiring merely a separate rheostat and a separate switch to substitute rheostat for meter movement when desired.

The instrument was built for a particular amateur station, the metered units of which are the HT37 transmitter-exciter, the Johnson Thunderbolt linear amplifier (with two meters), the standing wave voltage ratio indicator and antenna coupler (for adjusting transmitter to transmission line), and a Collins Communications receiver (signal strength meter). For the last named meter, the need was obviously not for a single fixed comparison tone, but rather for a comparison range calibrated to simulate the *S*-meter scale. This need was met by using not one but two rheostats connected in parallel (one a 1 MΩ unit and the other a 100,000 Ω unit), both initially set for maximum resistance. Then the 1 MΩ unit was gradually reduced in value until the resulting comparison tone was identical with that produced by the voltage drop across the *S*-meter at full-scale deflection. At this point the 1 MΩ control was locked, and the 100,000 Ω unit was calibrated and then fitted with a pointer knob. The needed calibration range could have been secured in other ways (notably by means of a calibrated potentiometer in series with a calibrating resistance, with this series combination connected across a separate voltage source) but the method chosen requires few parts and no separate battery source.

A shielded cable terminating in a shielded plug was brought out from each piece of equipment, i.e., from the terminals of each meter to be monitored.

The Meter Monitor is housed in a 3-inch by $5\frac{1}{2}$-inch by 10-inch metal utility box. On top of the box are the on/off slide switch, the rotary switch for selecting the various meters to be monitored, the comparison potentiometer for the receiver *S*-meter, and the several comparison tone rheostats with their associated momentary push-button switches. The latter are single pole, double throw units, so connected that each one acts to cut out the meter selecting switch and cut in the appropriate rheostat. On the end of the box jacks are mounted for the shielded plugs.

After every lead not at chassis potential has been filtered for rf energy, every jack is connected to its proper position on the rotary selector switch. The circuitry associated with the transistorized indicator is installed on a Cinch-Jones terminal strip, while the miniature transformer and speaker are mounted over a few small holes drilled in place of a grille in the end of the box. The miniature nine-volt battery, in series with the slide switch, is clamped to a side wall.

To ready the device for operation (i.e., to establish permanently the comparison tones) the station equipment and the monitor are actuated and each visual meter brought (with sighted help) to its appropriate reading. Then the tone heard from the loudspeaker at each meter reading is duplicated in the comparison tone circuit by manipulating the proper rheostat, and each rheostat is then locked at the proper point. After this the blind operator can readjust his equipment unaided.

A TACTUAL METER READER

W. EARL QUAY

Pennsylvania Association for the Blind, Harrisburg, Pennsylvania

In this section we consider electronic tools from the point of view of radio operators primarily, but devices developed in the amateur radio operator's workroom can and do have broader applications. Apparatus sensitive to changes in electrical values have potential application to many work situations.

My inclusion in this section was based upon contributions which I have made for the ham radio operator. All of these contributions have been small. I suspect that none are unique. So far as I know, I was the first one to publish directions for the construction of a transistorized auditory milliammeter, a device which uses comparison of pitches to indicate balance of electrical circuits. I believe that it had been done before but that the designers of equipment had not published the results of their findings. The fact that these contributions were made and that some of them were published in the *Braille Technical Press* emphasizes the importance of that publication. Those published items have been brought to the attention of blind readers of the magazine. This group, however, represents only a small percentage of the interested visually impaired. The *Proceedings* of this Congress will spread information even further but we are left with a glaring need for some regularly published vehicle to carry information on technical developments other than electronic aids. There is a need for a periodical which would not only carry information directed to it but which would also carry information on usable tools which have been ferreted out by other means.

A regular publication would disseminate information about all classes of adapted devices to assist blind people to promote their availability in a form usable by the blind. Some blind individuals are able to work toward the production of new devices and techniques and the necessary information should be readily available to them, as is the case with the *Braille Technical Press*. Perhaps an expansion of the *Braille Technical Press* to cover the entire field of adapted devices is necessary, both in braille and inkprint.

The description of the auditory milliammeter receiving comparison of pitches was, I believe, one of the first descriptions of aids published. Another tool which I have developed, a description of which has not been published, is a device to indicate audibly the percentage of moisture occurring in wood samples. This was used by blind workers in production of bent wood products in which determining the moisture content of materials is important. Plans for some other items, perhaps of lesser value in our work, have also been published such as a sound volume level indicator, an electronic keyer, a volume compressor, a voltage meter, and an inexpensive battery charger.

We have been stimulated to make another tool available which is probably neither new nor unique. This device is used to translate the readings of a visual milliammeter. The use of auditory null indicators or the use of comparison of pitches of an af signal to translate readings of a visual meter into usable form for the visually impaired person requires time and the manipulation of controls. The existing devices have limitations where rapid, random readings are to be taken in noisy environments and are not usable at all by deaf-blind persons.

The device accepts the small voltage drop appearing across a visual ammeter and transposes it into a mechanical motion on a large clocklike dial. It duplicates the visual meter readings, so to speak, so that the meter hand is not damaged or stalled in its motion by contact. A large amplifier, like a servo, might accomplish much the same purpose, for by this means large mechanical motions can be controlled by very small voltages. The attempt here, however, is to produce a compact unit within the purchasing power of most blind people and within reasonable limits of size and weight.

A schematic drawing to indicate the circuitry and components is available and can be supplied upon request.* For the benefit of those unable to use schematics a worded description of the circuitry is available also.

Auditory null indicators using pitch comparison require constant manipulation of controls to discover circuit balance. Neither of these can produce an indication of a fluctuating input nor are they usable in noisy environments. The device described would tend to overcome these shortcomings.

This new tactual meter reader would make it possible for tone-deaf persons to use measuring devices; it would have application in noisy environments; it would have application for deaf-blind people; it would have application where fluctuating values are to be read; and since the device can be read without adjustment of knobs or switches, it may be read with greater rapidity (see Figure 1). It may have application in industrial, laboratory, or hobby situations as well.

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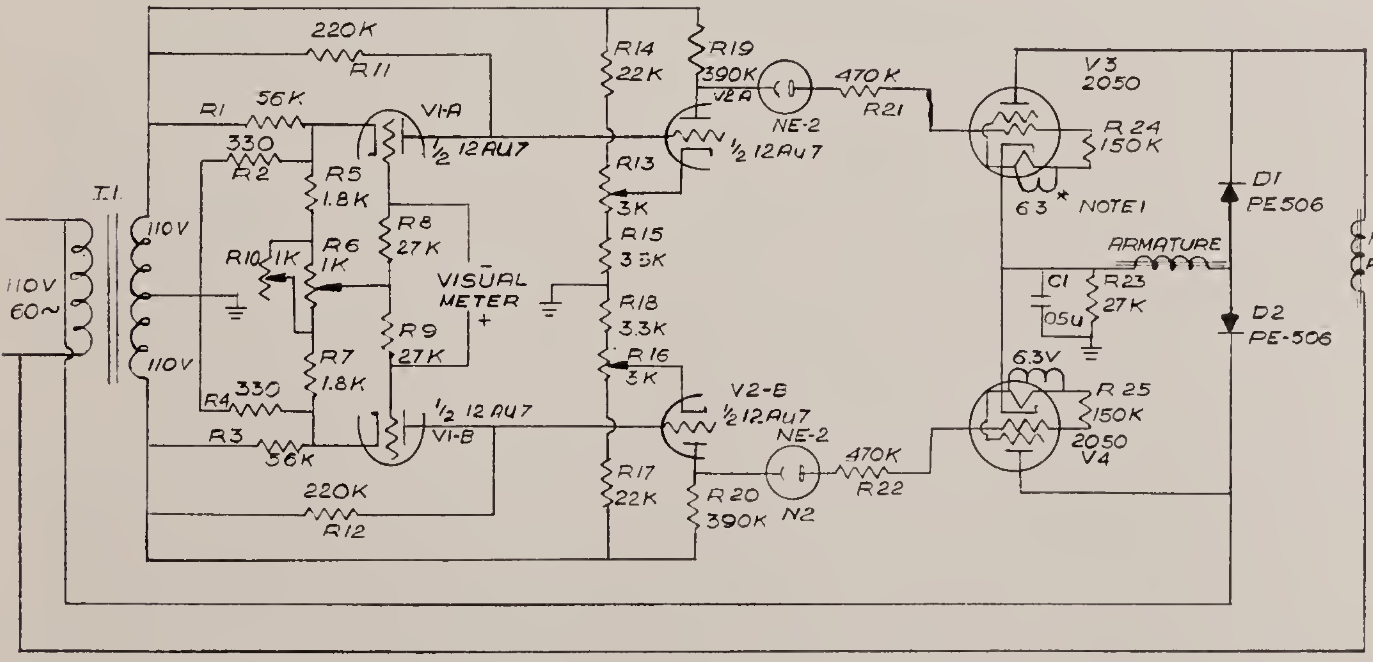
* To the author

The tactual meter reader receives the small voltage drop across a visual milliammeter. This voltage is amplified and used to trigger alternately one or the other of two thyratrons. These in turn activate a motor in one direction or the other. The motor is coupled to a large clocklike hand and to the shaft of a potentiometer. The resistive portion of the potentiometer is part of a voltage dividing network supplying bias to the amplifier tubes. When a voltage is applied to the amplifier by the visual meter, conditions of the circuit are upset and cause one or the other of the thyratrons to begin or end conduction. This causes the motor to turn the potentiometer in a direction which adjusts the bias to a quiescent condition once again. Balancing of the circuitry, by adjustment of the biasing potentiometer, occurs at different settings of the potentiometer (and of the clocklike hand), depending upon the variations in voltage applied from the visual meter. In practice the clocklike hand duplicates the readings appearing on the visual meter which has its terminals attached to the input of the device.

It is hoped that the production of this tactually read meter will stimulate a chain of improvements and refinements so that eventually a lighter and more compact unit will be developed.

I have been pressed for time in the completion of this device and hence there has been no opportunity to discover or correct any weaknesses in the design or execution. It is hoped that in its present form it will be useful and that its applications will be broad.



NOTE 1.
PHASE OF V3 AND V4 FILAMENT
TRANSFORMERS MUST BE CORRECT
TO PREVENT CONTINOUS FIRING
OF V3 AND/OR V4

FIGURE 1 Tactual Meter Reader-Circuit Diagram

ELECTRONICS AND THE BLIND

J. C. SWAIL
National Research Council of Canada, Radio & Electrical Engineering Division, Ottawa, Canada

PART I

GENERAL CONSIDERATIONS

Of all the scientific and technical fields that blind people have entered, electronics appears to be the most popular choice. This is due in part to a general interest in the subject today, but in the case of the blind there are a number of other contributing factors. Their interest in electronics might be centered around music (traditionally a field of activity for the blind) and the high fidelity set with its attendant electronics. Radio has brought to the blind news of the world and entertainment to a greater extent than any other medium. Amateur radio is a hobby in which many participate, probably because it is one activity in which a blind man may participate and compete at the operating level on the same terms as those with sight, and this participation frequently leads to an investigation of the electronics involved.

With the possible exception of braille, developments in electronics have done more than development in any other field of technology to free the blind from a dependence on sighted helpers. The radio, talking book, record player, tape recorder, and many adapted devices have gone a long way toward making information of all kinds available and improving the competitive position of the blind. Through the development and perfection of the tape recorder and other dictation devices electronics has opened up many new jobs to the blind. From such beginnings of acquaintance with electronics, many have developed a sufficient interest to seek knowledge, training, and then employment in this field. But many obstacles still confront the would-be electronics technician or engineer.

The first problem he must overcome is that of obtaining technical information in a form he can use. This is true, of course, of almost any profession the blind may enter, but electronics poses some rather unique problems. Although there are many kind people willing to read material onto tape, most of them are not equipped to interpret circuits and graphs.

The second problem is the production of schematic drawings from his own designs that a sighted technician can use.

The problem of coping with laboratory test and measuring equipment, without which he is virtually helpless, is a third difficulty. It is said (and it has been said to me), that the blind technician can use his brains and let someone else do the physical work. The lines of communication and interpretation between engineer and technician are sometimes rather tenuous, however, and it is necessary to be able to do one's own testing and measuring. I feel very strongly that without an adequate background of actual contact with the work, it is very difficult for a blind engineer to cope with good design practice, however thorough his theoretical knowledge may be. As a blind man wishing to pursue a scientific career, I have found it necessary to prove that I was capable of handling laboratory techniques, both before beginning university work and later when seeking employment. In the following section I shall deal with some of the techniques found useful in carrying out laboratory electronic tests and measurements.

In order to make the readout information from a laboratory electronic instrument available to a blind technician, it is necessary to provide dials with braille markings and to convert the readout signal into an audible or tactile form.

There is little difficulty in making capacity or inductance measurements, as most of the standard bridges used for this purpose are driven by audio frequency currents and employ headphones. Some bridges and other instruments use an electron ray tube as a visual null indicator. In these instruments the most effective auditory indicator has proved to be a voltage dependent af oscillator. The control potential applied to the visual indicator is applied simultaneously as bias to an af multivibrator or to a blocking oscillator. As this bias changes so will the frequency of oscillation, giving a rising or falling pitch heard in the headphones connected to the oscillator's output. The operator tunes the instrument for maximum or minimum pitch, which will correspond to the fully open or closed condition, respectively, of the eye tube. The use of voltage tunable oscillators has proved to be the most satisfactory method of dealing with almost any instrument in which only an indication of maxima or minima is required and no absolute measurement is required. Grid dip oscillators and other similar devices fall into this category.

Most of the instruments which the blind technician will encounter employ the moving coil meter and require a more accurate means of auditory indication than the af oscillator. There are various circuits designed to cope with this problem. Most are some form of bridge in which the voltage drop across the meter is balanced against the voltage developed across a precision potentiometer supplied from a stable source such as a mercury cell. The potentiometer is equipped with a braille scale and pointer and the dc imbalance across the bridge is converted to an audible signal through the use of some type of chopper (modulator). To determine the value indicated by the meter, the user adjusts the potentiometer for an audible null and reads the corresponding value from the braille scale.

In 1947, when I was first employed by the National Research Council, I developed a vacuum tube voltmeter which used a mechanical chopper, an amplifier, and a headset as detector (see Figure 1). Since then I have built many instruments, and converted many others, using this principle. With the recent trend toward miniaturization and increased portability of equipment, it has been found advantageous to use semiconductors. This has led to the development of a simple transistorized chopper which is much smaller, quieter mechanically, with lower electrical noise, and much more economical than its mechanical counterpart (see Figure 2). It consumes about 15 milliwatts, compared with the 300 milliwatts consumed by non-transistorized equipment.

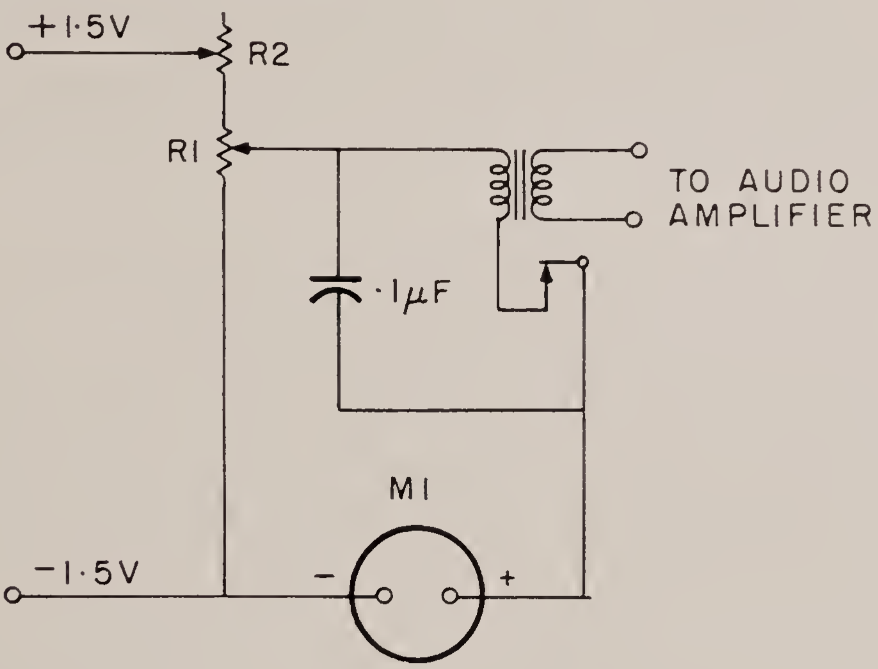


FIGURE 1 Auditory Meter Using Mechanical Chopper
R1—precision 500Ω potentiometer with pointer and braille scale; R2—10K calibrating rheostat; M1—any moving coil meter to be read.

This circuit has made it possible to develop a small precision volt-ohm-milliammeter for use by the blind, based on a relatively inexpensive imported

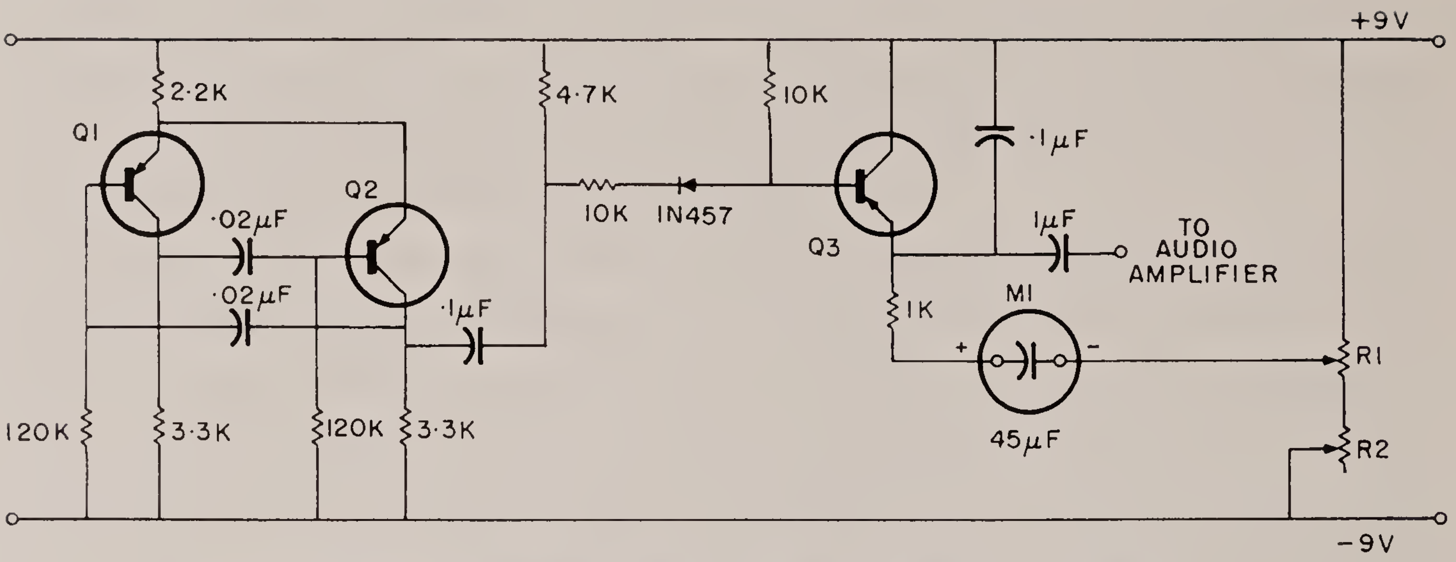


FIGURE 2 Auditory Meter Using Transistor Chopper
R1—precision potentiometer, 500Ω, with pointer and braille scale; R2—50K calibrating rheostat; Q1, Q2—transistors type 2N1377; Q3—transistor type 2N1379; M1—any moving coil meter to be read.

20,000 Ω/v circuit analyzer. The completed device measures less than 4 inches by 6 inches by 3 inches, weighs less than two pounds, and is housed in an insulated plastic case to free it of shock hazard. The instrument should cost about $40.

There are many other possibilities for reading metered circuits. Some include meter relays and a voltage sensitive oscillator.

The meter relay is built around a conventional visual meter which carries a second pointer, manually controlled. When the second pointer coincides with the regular pointer a pair of auxiliary contacts is closed (see Figure 3). The second pointer may be equipped with a braille scale, and the con-

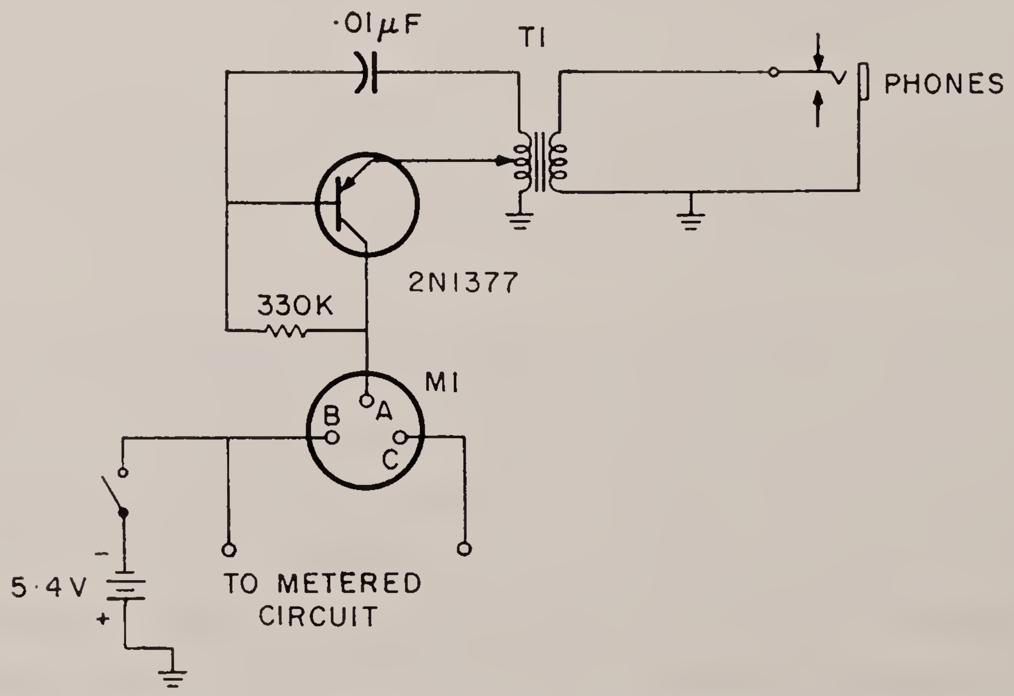


FIGURE 3 Auditory Meter Using Meter Relay
M1—$4\frac{1}{2}$ inches, 100 microamperes, dc meter relay, upper limit stop, manufacturers: Assembly Products, Inc., Chesterland, Ohio; T1—transformer: Hammond type 57009, primary imp: 1200 C.T., secondary imp: 16Ω.

tacts connected to an audio generator/headphone combination, enabling the operator to find the meter pointer and read its indication from this scale.

The voltage sensitive oscillator is a very useful device (see Figure 4). Through a unique arrangement of diodes in its feedback loop, it will go into or out of oscillation with a change of about 20 mv across its input terminals. Thus, if the metered circuit has a voltage drop of one volt or more, a control of variation within about 2 percent is possible with a very simple circuit.

I discovered recently a readout for certain types of electronic counters. One form, a transistorized counter, employs a set of 6.3 v lamps in a digital readout which may be replaced by solenoid-driven pins to form a raised matrix.

One instrument that has so far evaded any direct method of interpretation by the blind is the cathode ray oscilloscope. In my experience, it is possible to find other solutions to problems for which the sighted technician would normally use the oscilloscope. Thus, if it is necessary to determine a waveform distortion of a signal, a harmonic distortion analyzer with auditory metered readout may be substituted for the oscilloscope. Or if it is desired to determine the time delay between two pulses or wave fronts, an audible electronic counter used as a timer may be employed. Many other examples could be cited; these should serve to illustrate the point.

In summary, although I would never recommend electronics as an appropriate career for a blind person, I feel that if he is sufficiently interested and has the proper qualifications, most of the difficulties can be overcome somehow.

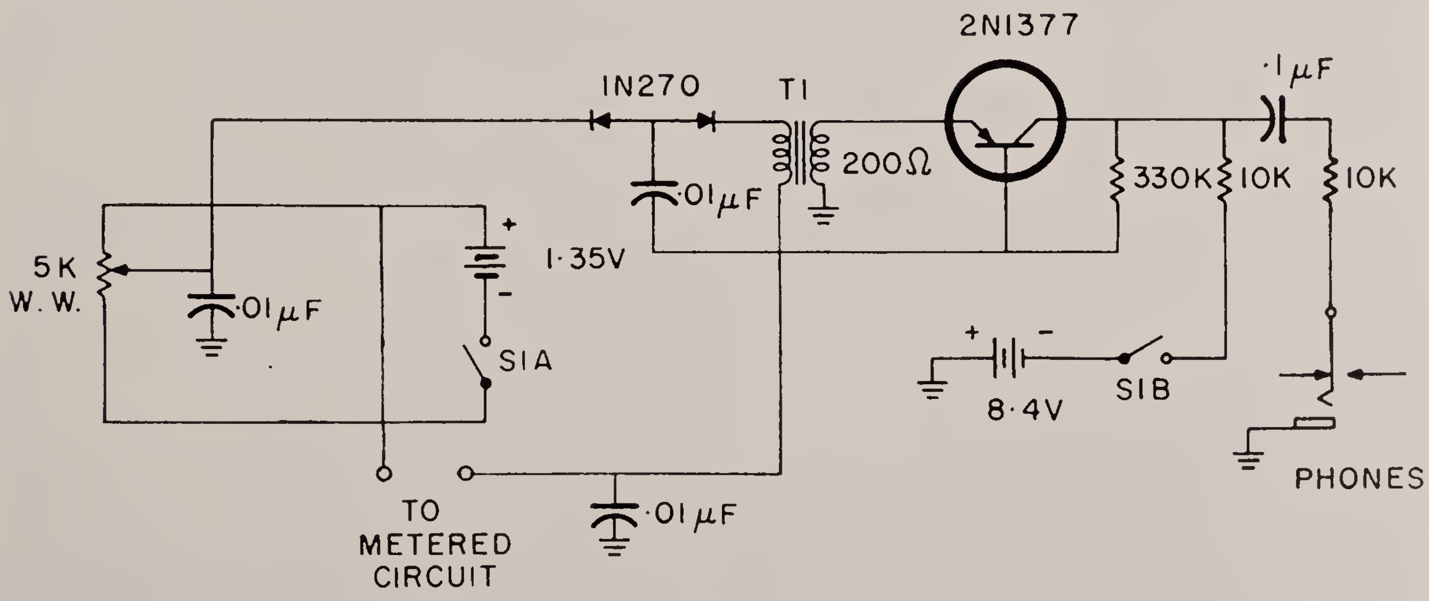


FIGURE 4 Auditory Meter Using Voltage Sensitive Oscillator
T1—Transformer: Hammond type 56715, primary imp: 200Ω, secondary imp: 1200Ω.

With the appearance of the *Braille Technical Press, Science for the Blind,* and volunteer reader organizations, the availability of technical information has greatly improved. Much remains to be done. It is still necessary to rely on some sighted reader for circuit interpretation.

In laboratory technique there is no serious obstacle either in construction or in making electronic measurements. It is doubtful whether any blind person could work quickly and accurately enough to fill the position of laboratory technician. It would seem more reasonable for the blind person interested in this field to aim for the higher achievement of designer or engineer, using his skills in actual physical work only to keep in touch with the work.

Note: Information on the voltage dependent tuned af oscillators has, for the most part, been obtained from the pages of the *Braille Technical Press.* The mechanical chopper circuit is similar in many respects to the circuits developed independently by Robert W. Gunderson and published in the *Braille Technical Press.*

PART II

WEIGH SCALE FOR USE BY THE BLIND

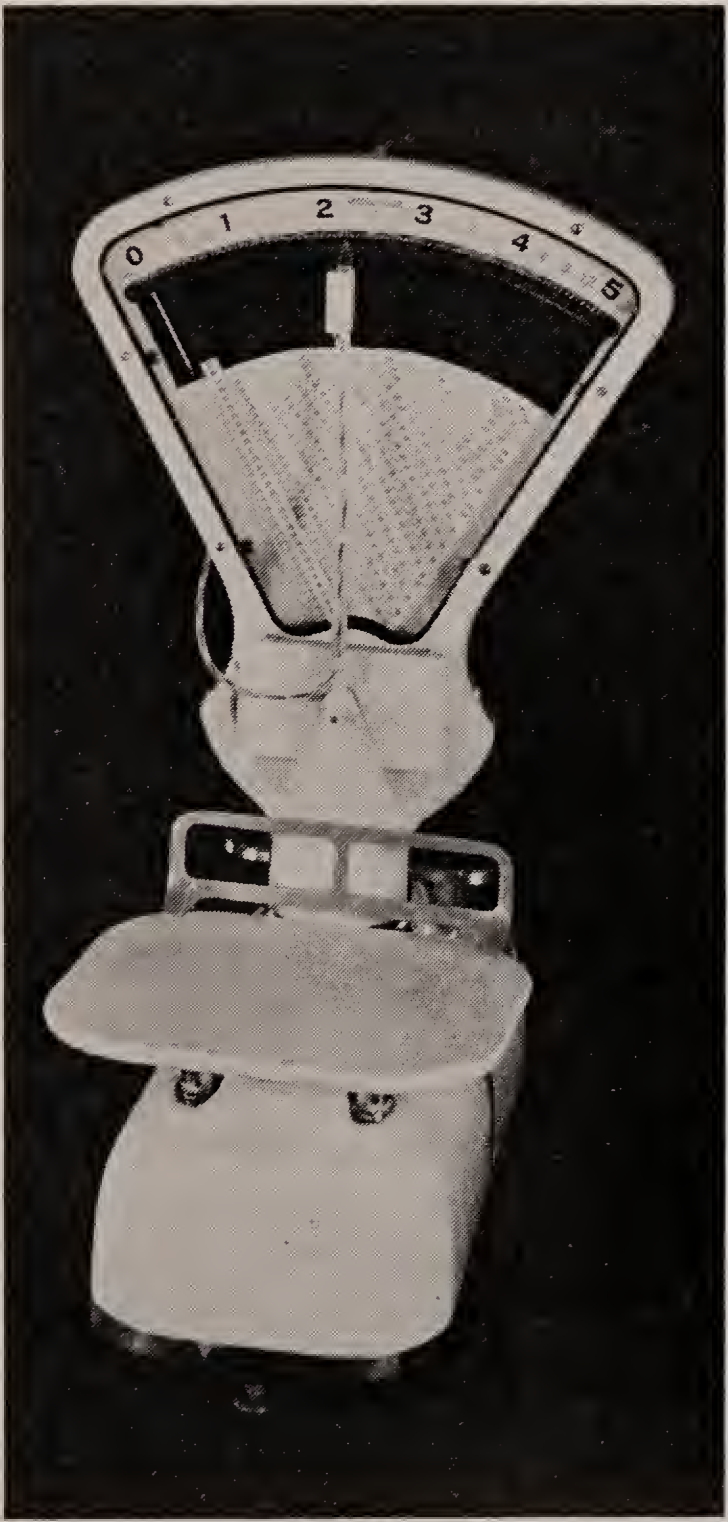
At the request of the Montreal Association for the Blind we undertook the task of modifying a weigh scale for the use of the blind. Until the modification was available, the blind foremen in the broom shop obtained sighted help in checking the weight of finished brooms to determine their agreement with predetermined standards and for members of the social service department to obtain aid in weighing parcels for mailing.

The first device built was fitted with a simple friction clutch made of fiber discs attached to the pointer of a standard spring balance. The balance had an open circular face about eight inches in diameter on which braille markings were placed to correspond with the printed numerals. Pressure on the clutch was released until the balance came to rest and the pointer was then clamped so that the user could feel its position without disturbing it. Although the device worked reasonably well, it proved to be insufficiently accurate; dust entered the working parts through the open face and grit from the contact of finger and fiber disc caused damage. A search was made to find a better balance for modification.

The Computogram scale, manufactured by the Toledo Scale Company

(Figure 5), was finally chosen as it has a large open scale with a range of two pounds. Weights in two-pound increments are added to a pan in the rear which permits a usable range of zero to 40 pounds.

The glass covering the scale was removed and the pointer and most of the face were painted black to minimize light reflection. A white line was painted along the center of the pointer and a new front cover was made of plexiglass with a braille scale made of small drive pins placed at one-ounce intervals. This scale corresponded exactly with the printed scale. An external pointer was mounted coaxially with the internal pointer, statically balanced and slightly friction-loaded by a simple fiber clutch so it could



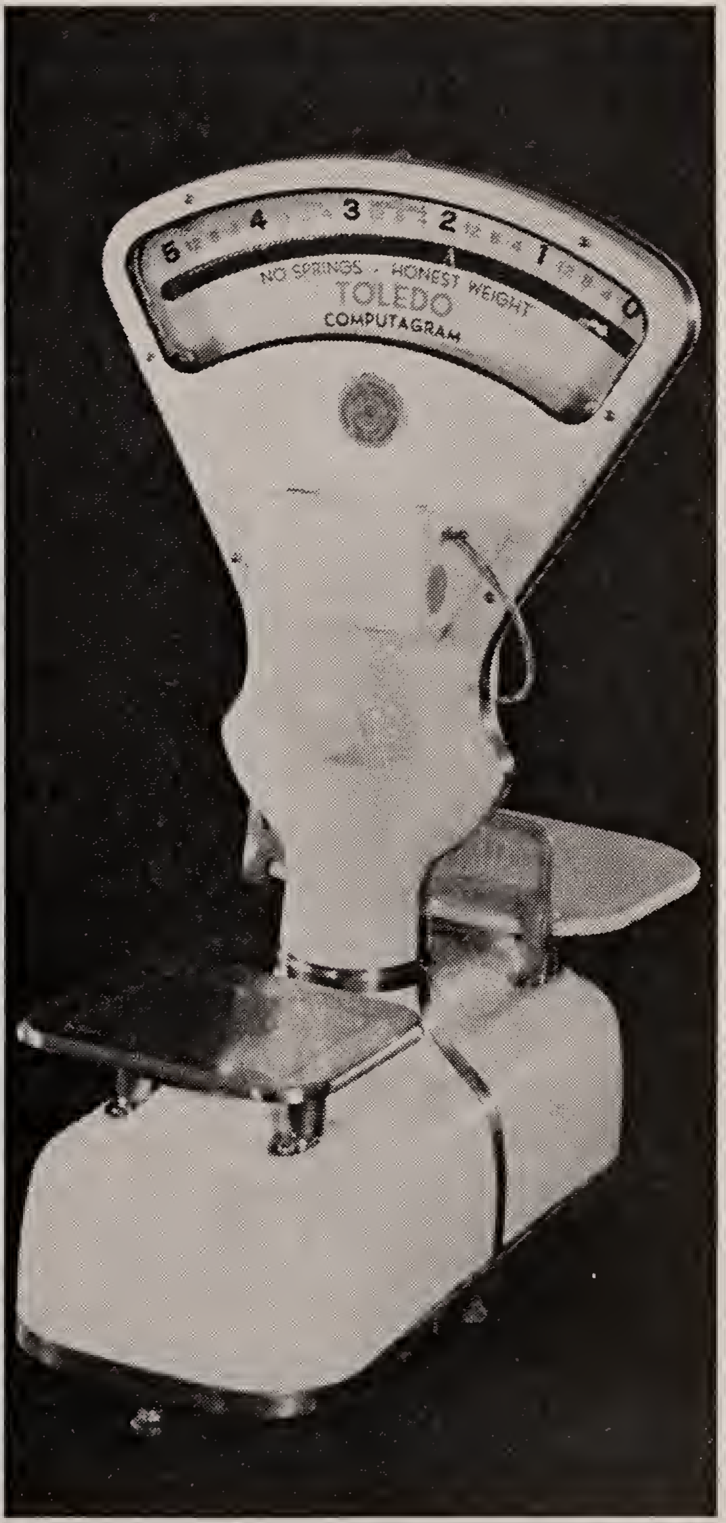


Figure 5a Weight Scale for Use by the Visually Impaired (Front View)
Figure 5b Weight Scale for Use by the Visually Impaired (Rear View)

be moved by the operator but would not tend to move if the scale were jarred.

At the end of this external pointer a small assembly, consisting of a prefocused $2\frac{1}{2}$-volt penlight bulb, a lens and a cadmium selenide photocell, was installed. Because the face is black, very little light is reflected back from the bulb through the lens when the external pointer is moved across the face of the instrument. When the two pointers are directly in line, however, light from the white center line is reflected back through the lens and to the photocell. The photocell is connected via a flexible cable to a unit consisting of a transistor audio frequency blocking oscillator, an audio amplifier and a loudspeaker (Figure 6).

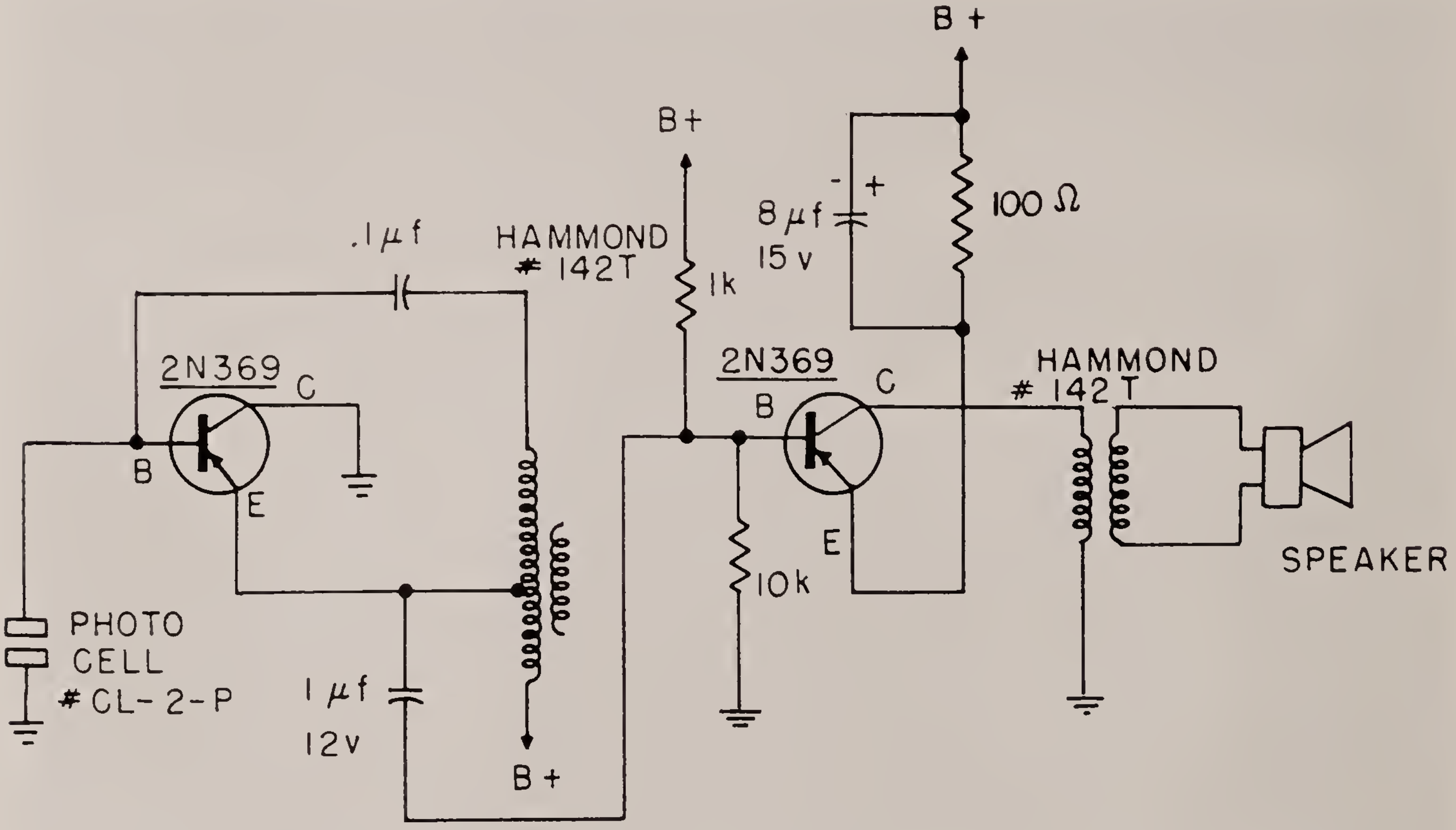


FIGURE 6 Weight Scale for Use by the Visually Impaired: Circuit Diagram

As the photocell is one of the elements determining the time constants in the blocking oscillator circuit, and since the properties of cadmium selenide are such that it changes resistance inversely with the amount of received light, the pitch of this oscillator will rise sharply when the external pointer is coincident with the white line on the internal pointer. While the pitch of the tone heard by the operator is about 100 cps when the external pointer is over the black scale face, it rises to over 1 kc/sec when directly centered over the white line and indicating the correspondence of the two pointers. The operator may then determine the weight from the braille scale on the cover.

This instrument has now been in service in the workshop of the Montreal

Association for the Blind for over two years, under fairly adverse conditions of dust and vibration. No servicing has been necessary except for normal battery changes. A totally blind operator, with only a few minutes briefing, can make measurements readily with a reading accuracy of less than one-half ounce. Measurement takes only about five seconds. The modifications do not hamper the sighted operator in using the scale.

The instrument has fulfilled its promise and has proved to be another help for the progress of the blind worker toward independence.

Note: The author wishes to acknowledge the technical assistance of Mr. E. J. Doyle in the preparation.

PART III

TAPE RECORDERS ADAPTED FOR USE BY THE BLIND

The tape recorder is one of the most useful tools available to the blind person. Not only can it serve as a medium of entertainment but it is almost invaluable as an educational device. In recent years many volunteer groups have been organized for the purpose of reading textbooks, magazine articles, and current events onto tape for use by the blind. The tape recorder and its attendant library of tapes have made it possible for many blind people to take employment which formerly was closed to them. To the blind person the tape recorder may be a personal notebook, a means of copying classroom notes and lectures, a means of dictating letters or of copying broadcast programs, and a means of actual correspondence. In using the tape recorder, the blind user has little difficulty in mastering the controls. Two serious problems remain to be overcome. The first is to devise a good way of indexing; the second to provide a means of monitoring recording level.

The author can testify from his personal experience that nothing can be more annoying than looking for a particular piece of information in the middle of a long tape. Without some type of tape position indicator, no useful form of indexing is possible. It is sometimes of great importance also to know when one is approaching the end of the tape; it may be disastrous to run out of tape when making an important recording.

The recording level meter is also of great importance. It is true that if the recording permits a trial run to check recording level, such a device can be dispensed with. But if the material is such that there will be no second opportunity to record it (e.g., a classroom lecture or a broadcast program), a level meter is vitally necessary. Levels can vary so widely under lecture or classroom conditions that there is no point in trying simply to learn appropriate settings of the gain control. This technique may be reasonably useful in copying radio programs if broadcasters hold levels reasonably constant (as they are supposed to).

Position Indicators

Two approaches to the position indicator have been developed. It is unfortunate that most of the commonly used counter or cyclometer indicators do not lend themselves to conversion for use by the blind. This is so because the drums used on these devices are too small to carry braille markings and, furthermore, as the numbers change rapidly it is very difficult to identify them by touch.

One such counter can be used. This is the clock dial counter manufactured by Wright and Weaire, Ltd. of England which bears their catalogue designation "Type CTA," as used on the British Ferrograph tape recorders. This counter is about $1\frac{1}{2}$ inches in diameter (about the size of a man's braille watch), and is fitted with two hands as in a clock. If the glass is removed and the metal rim used to hold the glass in place is turned down, a set of braille dots may be placed around the face. A certain amount of care must be exercised by the user to feel the hands while running the machine on Fast Forward or Rewind. With a little practice, no difficulty should be experienced. Although normally supplied only on the Ferrograph recorder, this type of counter could be installed on many other makes, either by punching an appropriate hole in the tape deck or through the use of a small bracket mounted on the side of the recorder. In the Ferrograph machine the device is driven from the take-up spindle via a right angle gear and flexible drive. This may not be practical in other makes. If not, a small pulley may be installed on the shaft which protrudes from the side of the counter which may be driven by a belt from the take-up spindle. The indexing accuracy of this device is quite remarkable; the author has been able to find his place in the middle of an 1800 foot tape within about 20 to 30 seconds.

The approach tried uses a light metal arm held in contact with the tape on one of the reels by spring tension. This arm rotates on a rod mounted to the recorder deck. The end of the arm is shaped like a cam. A second arm, also free to rotate about another rod mounted on the tape deck, has one of its ends riding against the cam while the other end carries a pointer moving along a braille scale. The cam is so shaped that there is a linear relation between the number of feet of tape on the reel and the reading on the braille scale.

The advantage of this latter device is that it is much cheaper to manufacture and is more easily installed on a recorder. But it is not nearly so accurate as the first device. The total display of the amount of tape on the reel covers a four-inch length of braille scale, whereas the first device displays this quantity on a 0 to 1000 counter.

Level Meters

A number of these devices have been described in the *Braille Technical Press*. Many fall into the general category of biased diodes which permit an impulse of electrical energy to pass into the earphones when the signal voltage exceeds the bias. Four alternative approaches of this general design will be described.

1. Meter relays: Several companies market a meter which has two pointers. The second one is controlled by a knob on the meter face. The second pointer may be set to any desired scale reading. When the current through the meter causes the pointer to deflect to this value, contact is made between the two pointers and closes a pair of contacts which may be used to control any desired external circuit. If the recorder to be modified has a level indicator meter, one of this type having the required sensitivity may be substituted, whereupon any convenient auditory or tactile transducer may be operated by the contact switch.
2. Voltage sensitive oscillator: Use can be made of a special form of transistorized blocking af oscillator which is so arranged that it will not oscillate until the voltage difference between its two input terminals reaches some accurately known value (Figure 7). This circuit is sufficiently sensitive that it will trigger reliably within 20 mv of this value. If a rectified af voltage, derived from the monitor output of the tape recorder, is applied to one of the input terminals and a calibrated dc bias voltage applied to the other input terminal, the device may be set to trigger or oscillate at any preset recording level. The advantage of this device is that the level of the output signal from the oscillator does not change with the amount of input signal, provided that signal is above the threshold level. Because of the time

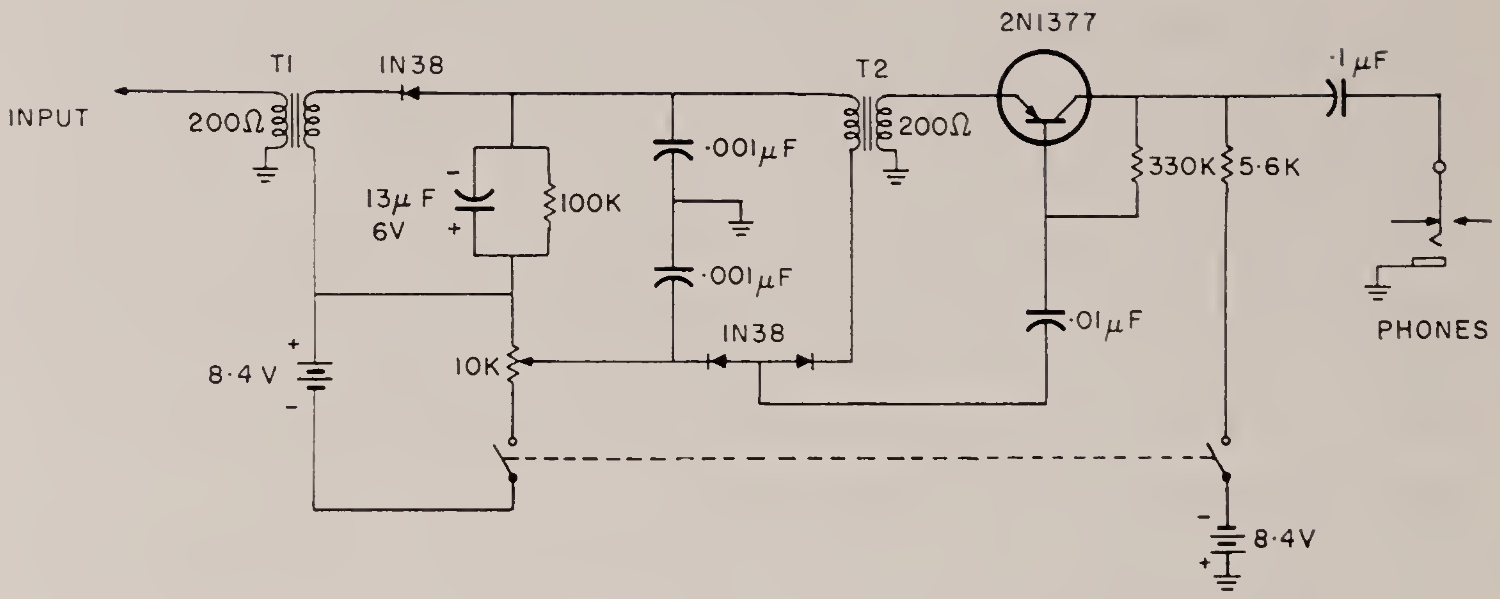


FIGURE 7 Auditory Level Indicator Using Voltage Sensitive Oscillator: Circuit Diagram
T1, T2—transformer: Hammond type 56715, primary imp: 200Ω, secondary imp: 1200Ω.

constants involved in the rectifier circuit, it will continue to oscillate for a short time after the peak has been passed. This device gives a very precise indication of the peak recording level, and in experimental use, the gain control can be set to within 2 or 3 percent of any predetermined setting.

3. Tactile output indicator: In many circumstances an audible output is not desirable as this in itself may interfere with the recording being

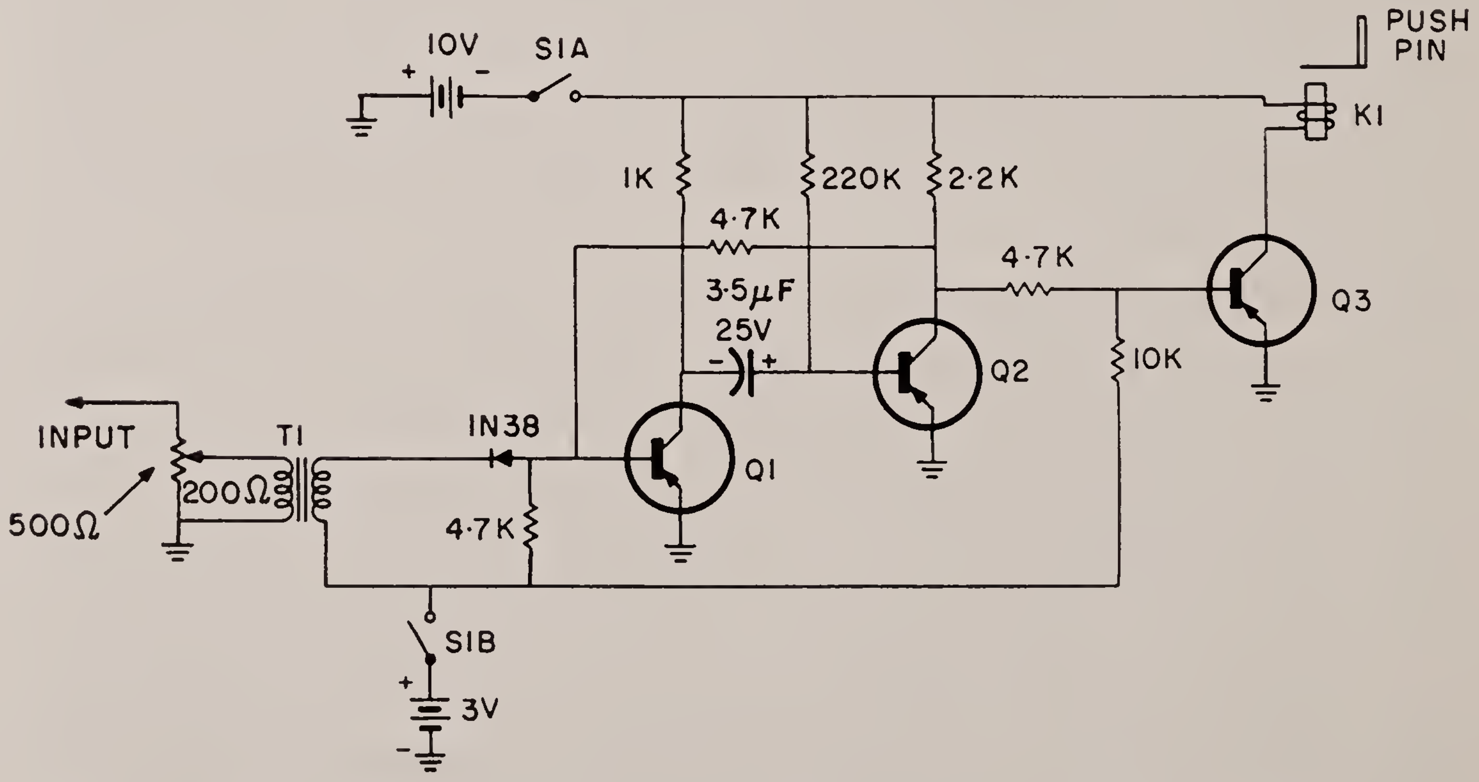


FIGURE 8 Tactile Level Indicators: Circuit Diagram
T1—transformer: Hammond type 56715, primary imp: 200Ω; Q1, Q2, Q3—transistors type 2N1377; K1—relay: Potter & Brumfield type GPO, coil 12 v dc.

made; earphones may also be impractical. Under these conditions a device with a tactile output is more desirable. The output device chosen is simply a small plunger driven by a solenoid (Figure 8). The solenoid is connected as the load in a simple transistorized dc amplifier which is controlled by a transistorized univibrator. This circuit is biased so that it will only operate when signals applied to it from the tape recorder monitor jack exceed some preset level. This is probably the most satisfactory of all the devices cited, for it is simple, relatively inexpensive, and leaves the user's hearing unencumbered. The time constants of the univibrator are chosen so that when a pulse from the recorder has triggered the device, the plunger will remain up for about a half second.

4. Cadmium selenide photocell: Another possibility is to use a simple af blocking oscillator whose frequency is controlled by the changes in resistance of a cadmium selenide photocell. This simple device is useful with those recorders having a magic eye as a level indicator. The photocell is placed close to the eye and the pitch of the oscillation heard in the earphones changes as the recording level changes. Although this approach can be quite successful, it is not exact and requires a certain degree of skill to use it.

In conclusion it may be seen that with suitable attachments a blind tape recorder operator need be at no disadvantage when compared with his sighted counterpart.

THE USE OF THE ABACUS (SOROBAN) IN ELECTRONIC CALCULATION

FRED L. GISSONI
State Bureau of Rehabilitation Services, Frankfort, Kentucky

If we were to liken the field of electronics to a radio transmitter, we would surely think of mathematics as its power supply. The student of electronics cannot hope to escape the need for making arithmetic calculations. This is true whether the student is sighted or blind.

If the would-be electronic expert is sighted, he may do his calculations with pencil and paper, slide rule, or mechanical or electrical calculating equipment. But what are the means available to a blind person who needs to solve these same problems?

He may attempt to make the entire calculation mentally; or he may use braille; or he may choose to use one of the arithmetic slates. Still another choice is to have someone else do the calculations. Or he may simply abandon his interest in areas which require arithmetic calculation; this is probably the most common solution. The means which are now available to blind people who have need of arithmetic are awkward, cumbersome, slow, and mechanically inefficient.

Before beginning a discussion of the abacus as an arithmetic aid, let me cite a few characteristics which would be desirable in any practical arithmetic aid for the blind.

1. Economy: The aid should be inexpensive to buy and maintain.
2. Portability: It should be small enough in size and light enough in weight so that it can be carried and within easy reach when needed.
3. Speed: A practical aid should enable calculations to be made with maximum speed. Instantaneous calculation is of course the ideal, but practical considerations dictate that we settle for something less.
4. Accuracy: The ideal aid should permit calculation to several decimal places. There should be no need for guess work or interpolation.
5. Automatic Operation: The operation should be automatic if possible. While the operator should be freed from the necessity for mental

calculation, his use of the aid should not distract him from more abstract thinking.

6. Record Keeping: The ideal aid would contain a storage section which would retain a permanent record of calculations, thereby providing a means for checking each step in the calculations.
7. Compatability of Operation: The ideal arithmetic aid for the blind should be operable by both blind and sighted people. No special training should be required of a sighted person in order to read the aid, and the device should be direct-reading if possible.

This paper is to be a discussion of the abacus, specifically the soroban. Abacus is a generic term applied to all reckoning boards using beads mounted on rods. The soroban is a Japanese version of the abacus having one bead above the separation bar and four below on each column.

Having established some standards for an ideal arithmetic aid for the blind, let us see how they are met by the soroban type of abacus.

1. Economy: The soroban, which has been adapted for use by the blind, will be available eventually through the American Printing House for the Blind; it will probably cost about $5. We hope it will be somewhat less than this. Since the abacus is a self-contained device, there are no accessories to buy.
2. Portability: The soroban weighs approximately four ounces and is small enough to fit into a man's pocket or a woman's purse, where it will be within easy reach.
3. Speed: The speed attainable by blind operators of a modified abacus is potentially greater than that of a sighted person making pencil and paper calculations.
4. Accuracy: The accuracy attainable with the abacus is equal to that of the most sophisticated digital calculator in general use.
5. Automatic Operation: The abacus must be manipulated by the fingers of the operator. Thus it is not automatic. The results, however, require no mental calculation on the part of the operator. Once he learns a short series of rules for correct hand manipulation, the operator can make the most involved computations with no mental calculations. He simply moves beads up and down on appropriate columns and reads the final result. This "automatic" calculation of the final result does not deprive the operator of his insight into number concepts. On the contrary, it is evident from the skill with which Japanese soroban operators are able to do mental arithmetic that number concepts are sharpened, and the ability to do mental arithme-

tic increases. To those who see this statement as an apparent contradiction, let me say that when an abacus operator reaches a high level of skill, he is able to work problems of a surprisingly high order of complexity on an imaginary abacus.

6. Record Keeping: Unfortunately, the abacus does not have a permanent recording device. There is no way for checking the steps in one's work. If there is any question as to the accuracy of a piece of work, it must be repeated. If results are to be retained, they must be recorded elsewhere.
7. Compatability of Operation: The operation of the modified abacus is identical to the operation of the conventional abacus used by sighted people. A sighted operator could operate the Cranmer Abacus for the Blind (currently under field test) with no additional training. Learning to read numbers on the abacus is simplicity itself. The operation of the abacus will be discussed later.

In his paper entitled "The Abacus as a Mathematical Aid," Mr. T. V. Cranmer, developer of the Cranmer abacus for the blind, sets down some detailed descriptions. It will suffice to say that the Cranmer abacus for the blind is a rectangular frame which measures about 3 inches by 5½ inches, and contains 13 columns of five beads each. A separation bar separates four of the beads on each column from the fifth. In the operating position, the single bead above the bar has a value of 5. Each of the four beads below the bar has a value of 1. Thus the digits from 0 through 9 can be represented by proper placement of the beads. For a number to take on its value, the appropriate bead configuration must be moved toward the bar. When beads are moved away from the bar, the column represents either the digit 0, or is unused.

Behind the beads there is a pad of foam rubber covered with felt which offers resistance to bead travel. It is this modification which makes the abacus operable by blind people. Touching a bead to read one's work does not displace it and destroy the result, as is the case with the unmodified abacus.

Upon the face of the bottom member of the abacus frame, a dot has been placed at the end of each column. In addition, a line has been placed between columns at three-column intervals. This line, called the "unit mark," stands for the comma as used in written arithmetic. It may also serve to represent a decimal point. It is extremely valuable in making computations for electronic work with the abacus.

It is not my purpose to teach the use of the abacus. Time would not permit. I will work through one application of Ohm's Law, for the purpose of giving an insight into the simplicity and value of the abacus as an aid to the blind person interested in electronics and other branches of technology.

Let us assume that we have a 16 MΩ resistor. Through it, we have a current flow of 125 μa. What is the voltage drop across the resistance? If we multiply 125 μa by 16 million, we will find that we have a 2000 v drop. Now, let us do this on the abacus.

We begin at the left end of the abacus and find the first unit mark. To its right, we leave three columns in the 0 condition and set the number 125 on columns four, five, and six to its right. This will now represent .000125 amp. Next, we multiply the 125, not by 16 million (as you might suppose) but simply by 16. This is done with amazing speed, but we are surprised to learn when we finish that the only active digit which seems to appear on our abacus is 2. We have no idea how many zeros come before or after this 2. So, we return to the unit mark from which we started. Then, we apply the simple rule for the location of the decimal point. We proceed to the right by a number of places equal to the number of digits in our multiplier, plus one additional place. Sixteen million is an eight-digit number. The allowance of the extra place gives a total of nine places to move to the right. It is at this point that we find the decimal point of the product. Now we find the digit 2, and count three places to the right to find the decimal point. This means that the three columns to the right of the 2 are in the 0 condition. Two followed by three zeros is the number 2000, which is the correct answer.

While this may sound complicated, it is easier to do than to describe. There is no problem in distinguishing between zeros and unused columns once the operator has mastered a few simple rules of decimal placement.

Recently a friend of mine was building a capacitance meter. The device contained an oscillator having a capacitance of 1200 $\mu\mu f$ in its circuitry. My friend wanted to know how much frequency shift would result in a 1 $\mu\mu f$ change in the tuned circuit. He could have breadboarded the device, but this would have been extremely time-consuming. He could have used braille or one of the arithmetic methods available to the blind. However, my friend happened to be a skilled abacus operator, and he was able to make the calculations and check the results in three or four minutes. He telephoned me the news with great excitement, and later he was thrilled when he built the instrument and his mathematical accuracy was confirmed.

You may be wondering just how long it takes to learn to operate the abacus. In the course of our field testing program, we plan to teach abacus calculation to a number of blind people. We plan to give ten hours of instruction over a ten-week period. At the end of this time, we expect our test subjects to be able to perform any arithmetic calculation on the abacus. Their ability in arithmetic with and without the abacus will be tested.

Another reasonable question is, "When will the device be available?" We feel it is safe to say that both the abacus and an instruction manual, in braille and sound recording, will be available no later than June 1963. It may well be that a sufficient expression of interest will make it possible to hasten availability of the abacus.

I am not a mathematician. Speaking as a layman, I must say that using the abacus has made it possible for me to handle my own rather ordinary need for arithmetic much more efficiently. It is my belief and that of Mr. Cranmer that the abacus can do as much for other blind people as it has done for us.

THE USE OF ELECTRONIC AIDS FOR THE BLIND IN GERMANY

KARL BRITZ
Verein der blinden Geistesarbeiter, Marburg/Lahn, West Germany

Until a few years ago only sighted men could explore and study physics, apply what they learned to invention, and develop new techniques and devices. Yet an interest in such matters is not confined to the sighted. Persons with impaired vision are in fact especially interested in techniques, since they are constantly searching for ways to compensate for their handicap. While the technological revolution has entered nearly every other area of human life, a social advance of previously unknown dimensions was necessary before blind persons, for example, were enabled to approach the study of science and technology and do productive work in these fields. An impulse toward this advance was given by amateur radio, a hobby which is opening new doors to the enquiring blind, who are easily isolated because of their handicap. Both their technical interest and their desire to find new friends explains in fact the reason why many blind persons are found among radio amateurs throughout the world, especially in technically highly developed countries. About 50 blind radio amateurs are now registered in Germany, and their number is growing.

These radio fans, and also those interested in technology and science in general, encounter the same problems in pursuing their interests in Germany as elsewhere. The first problem is the lack of technical literature. Only a small number of books has been transcribed into braille; very few books have ever been embossed in large numbers. Of these, nearly all are "popular science" in orientation and their educational value is therefore rather limited.

One remedy for this deeply felt lack of literature—in this case for radio amateurs and for those interested in electronics—is seen in the publication of a special periodical. In the summer of 1953 the first issue of *Der blinde Bastelfreund* appeared; it is now published quarterly. The magazine is much smaller than the *Braille Technical Press,* published in the United States, but the content is similar. The ten volumes published to date contain quite a lot of fundamental and advanced knowledge, and practical instruction as well.

When this magazine was founded one great difficulty was seen to exist in representing electronic circuits. An enlarged and embossed reproduction of circuits was impossible because of the high cost. Therefore it was decided to describe the diagrams verbally (as practiced in the *Braille Technical Press*), using reasonable abbreviations for the various components in such circuits. As it turns out, the space for the representation of a circuit is about the same as in inkprint (an unabbreviated description would need at least twice as much space). Such a representation of circuits can be independent of the peculiarities of any particular language and thus comprises an internationally comprehensible means of communication.

The second problem encountered by the blind radio enthusiast is the lack of measuring instruments. This problem has not yet been attacked seriously. But it seems not impossible that electronic devices will soon be available for measuring voltage, current, resistance, temperature, and the like.

As a contribution to filling this need and as a supplement to the many proposals already published in the *Braille Technical Press* over the last few years, I shall describe a little instrument suitable for measuring voltage and current whose simplicity is unsurpassed. It operates as a Wheatstone bridge circuit, consisting in a potentiometer P and two resistors R and X. The series circuit of R and X is joined in parallel with P. Between the moving arm of P and the junction of R and X lies a null indicator, perhaps a "chopper" with earphone output. If the bridge is adjusted to zero, the position of a pointer connected with the shaft of the potentiometer gives the ratio of the values of R and X. We use as resistor X an element whose electrical resistance depends either on the current flowing through it or on the voltage at its terminals. That means that the value of X will depend upon the voltage applied to the terminals of the potentiometer. Accordingly, the zero position of the pointer varies with and is characteristic of this voltage. The component X can be supplied from a glow lamp (neon bulb), a diode, or any other nonlinear resistor. A glow lamp, for example, changes resistance in a ratio of 1 to 10 from normal room temperature to normal operating temperature. In Figure 1, the following values have been assigned: Resistor X is a lamp designed for 10 volt, 50 ma operation, while the comparison resistor has a value of 20 Ω. To spread the scale of the pointer across the whole length of the potentiometer P (1 KΩ), two resistors are connected in series with the potentiometer, with 2 KΩ on the side contain-

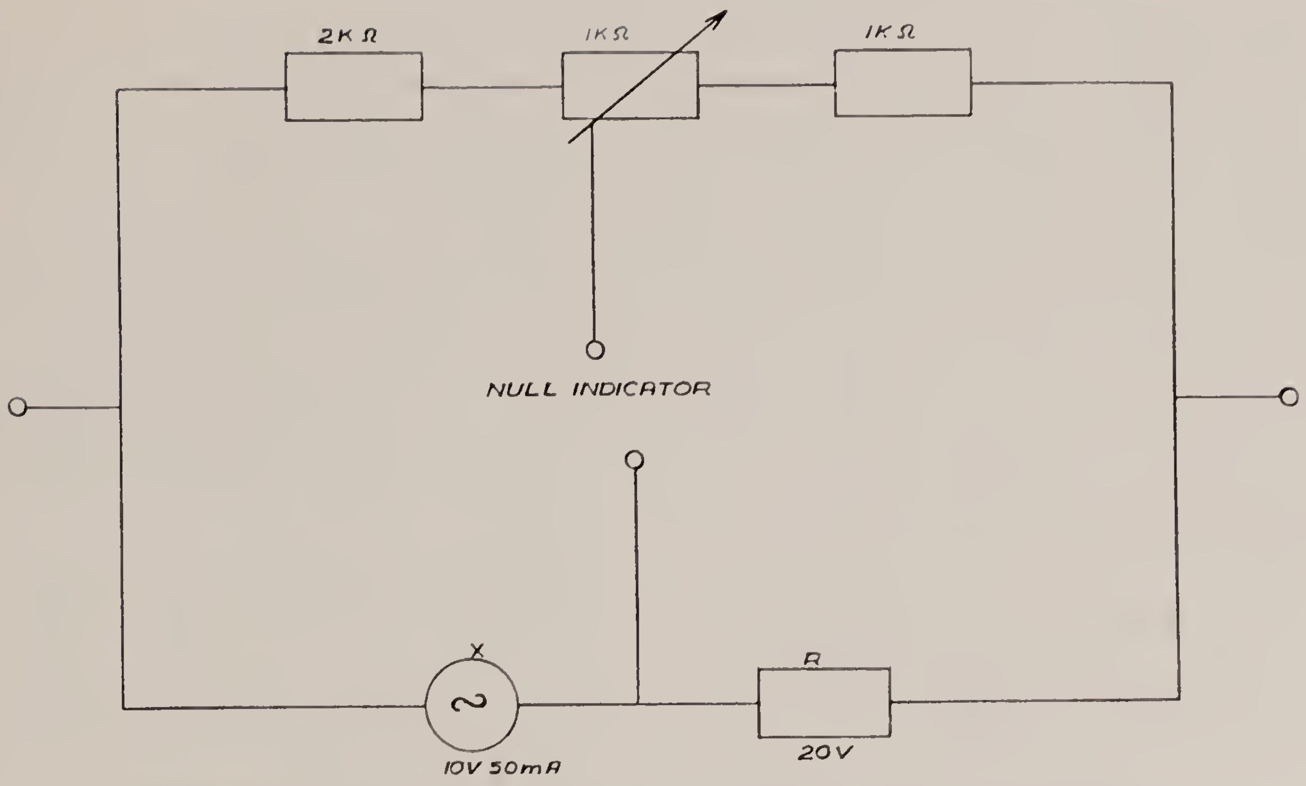


FIGURE 1 Circuit of a Simple DC-AC Measuring Device

ing resistor *X*, and 1 KΩ on the side containing resistor *R*. This instrument works in a current range of 2 to 16 ma, corresponding to a voltage range of 0.05 to 1.3 v. With suitable shunt or series resistance the device can be used as an ammeter or as a voltmeter. The configuration is a simple one; but it has one fault: if the values for the shunt reisitors are not chosen carefully (so that the current flowing through the measuring unit causes a voltage drop which can be ignored) measurement is a little complicated, for two readings become necessary, one for voltage and one for current. The reason for this is that the instrument must be equipped with two scales for these two quantities which are nonlinear and thus differ from each other. In spite of this the instrument can be very useful. With neon bulb supply it can be used for both dc and ac measurement (the latter without a rectifier) up to frequencies as high as 25 kc/sec, while with diode supply it is adapted admirably to measurements of dc μa.

The main problem in electronic work for the blind person is in soldering. To use a normal soldering iron is not possible, for it is kept at a very high temperature; this endangers the operator's fingers by burning. One solution of the problem may lie in the soldering gun which heats a small metal loop within a few seconds to a temperature which melts tin. This is useful, however, only in soldering small joints, i.e., thin wires and the like. Large conductors cannot be soldered this way since the heat flows away from the joint too quickly. The utility of the soldering gun is thus limited. A better solution of the problem, useful even for soldering metal sheets of considerable thickness to one another, lies in using a sharpened carbon rod as the heating element. It is connected to the low voltage side of a transformer, while the other terminal is joined to the tinning wire with an alligator clip. The point of the carbon is then pressed gently to the soldering seam whose top side is touched with the tinning wire. The carbon rod heats quickly, and the whole operation may take but a few seconds even for large joints (this method was even applied successfully to holes in the bottom of iron pots). About 5 to 10 v pressure is needed, and currents of about 20 to 40 amps flow through the joint. The transformer must of course be made large enough to supply this current flow.

The advantages of this method are that the soldering element may be laid among cold objects after using it; that the joint is heated very quickly; and that the soldering tool cools very rapidly. Figure 2 shows how the tool can be used. The carbon rod is from a normal flashlight battery and has a diameter of 6 mm. It is inserted into one end of a copper pipe having a 6 mm i.d. and 7 mm o.d. Into the other end a 6 mm brass pipe is inserted into which the stranded wire of 2 mm^2 is soldered.

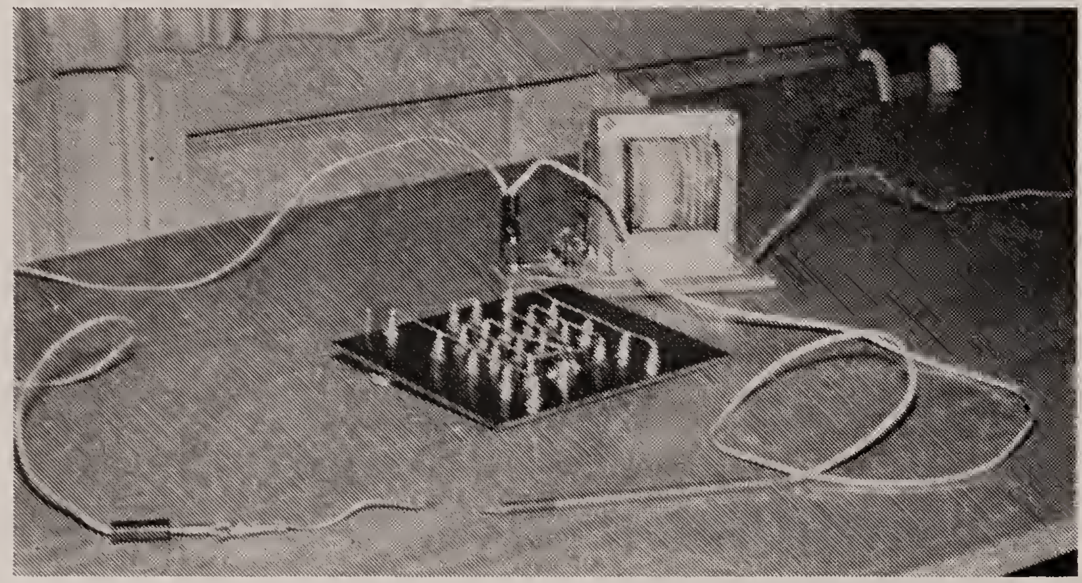


FIGURE 2 High Current, Low Voltage Soldering Aid for Blind Technicians

The problem of soldering may be considered solved by this means. Unfortunately the solutions of many other problems are so far no more than good ideas.

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